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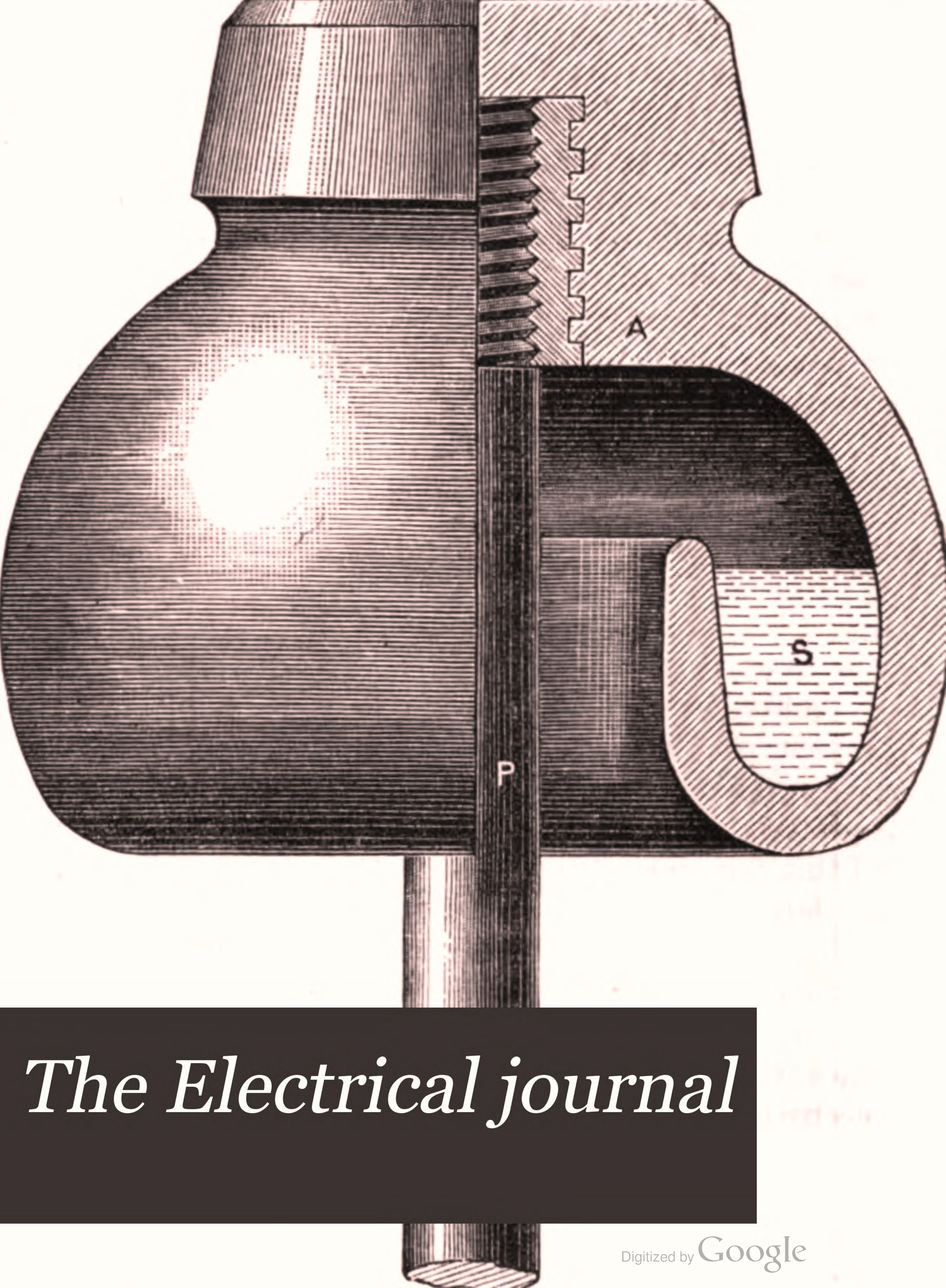

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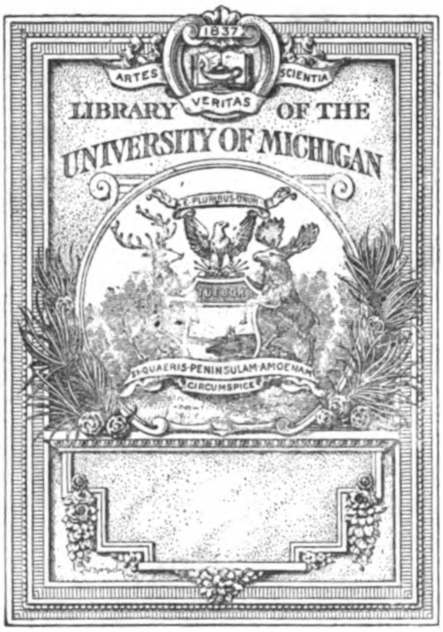

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1.—Vol. III. SATURDAY, MAY 24, 1879. Price 4d.

NOTES.

The Cape Cable.—This cable is being rapidly manufactured at the works of the Telegraph Construction and Maintenance Company, Greenwich. As we have previously mentioned, the ship Kangaroo took out the first portion of the cable, some 364 miles, and on Saturday, the 17th May, the s.s. Seine, a much faster vessel, we may add, than its predecessor, was despatched, having on board the second section of the cable about 1,400 miles. The next vessel will be the Calabria, which is expected round from Liverpool. The Calabria has just been fitted with new compound engines. A difficulty has been experienced with the coal necessary for so long a voyage as will be required of these vessels.

The New Theory of Terrestrial Magnetism.—We believe that experiments with a view to put this theory to a practical test, are contemplated by Professor Ayrton, and will be carried out so soon as all the requisite conditions can be arranged. It will thus be seen, with reference to a correspondence which we recently published on the subject, that on the one hand a practical demonstration, which was what Mr. Laister and others demanded, is admitted to be feasible and desirable. On the other hand, so far as we can see, there is no desire on their part to take credit for the suggestion, or to show a preference for one class of experiment rather than another—all that they advocated being the experimental rather than the mathematical proof in the first instance.

Enemies of Telegraphy.—An official report from Sumatra states that frequent disturbances of telegraphic communication are caused in that island by elephants. During the three years 1875-78 there have been 60 serious interruptions traceable to this cause. As an instance, this report says:—"On May 25, 1876, the Muara-Dura-Lahat line was completely destroyed for a length of three pauls, and the wires and insulators were hidden away in a cane thicket. All the repairs executed during the day were regularly destroyed by night, and this for three nights running. Besides the systematic hostility of the elephants, the numerous tigers, bears, and white buffaloes make it both difficult and dangerous to keep an efficient watch on the telegraph lines, where they pass through thick jungle. Both the greater apes and the little monkeys seem to regard the lines as set up for the purpose of affording them the opportunity of practising special gymnastic exercises, swinging from the wires, breaking them, and carrying off the insulators."

Death of Mr. James Adams.—We regret to announce the death in Paris, on the 4th inst., of Mr. James Adams, who for some time past acted as Mr. Edison's representative in England in all matters relating to the mechanism and application of that gentleman's several inventions. Mr. Adams's career has been remarkable. According to the *New York Herald* he was a native of Scotland, and shipped from there as a cabin boy early in life, remaining at sea for fourteen years. On his marriage in America he obtained employment as night watchman at Mr. Edison's works. His zeal and fidelity were soon rewarded by more intelligent occupation in the workshop, where the aptitude and ingenuity he displayed, coupled with an untiring energy, almost rivalling that of his employer, finally obtained for him a pecuniary interest in every invention turned out of the establishment. We are glad to learn that this interest descends to his wife and two children who survive him. He suffered from heart disease, to which he succumbed at the early age of thirty-three.

Thermo-electric Batteries for the Electric Light.—By an expenditure of 2lb of coke per hour, M. Clamond has succeeded in maintaining four electric lights, each having an illuminating power equal to from 200 to 250 standard candles. This result, which is said to be vouched for by M. du Moncel, would tend to prove that our anticipations as to the great importance of thermo-electricity in relation to electric lighting were by no means exaggerated. We hear also that M. C. A. Faure is in a fair way of even surpassing the above result. His small pile of 60 couples, intended to produce the effects of a large Bunsen cell, is a remarkably compact and practical piece of apparatus, giving an electromotive force of about 3 volts and having an internal resistance of about one-third of an ohm. His large battery for the electric light contains some 3,000 elements and is said to work at full power with an expenditure of 80 cubic feet of gas per hour, being quite equal to 50 Bunsen elements of very large size. Ample and accurate details in relation to this invention will probably be forthcoming very shortly.

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THE SOCIETY OF TELEGRAPH ENGINEERS.—At the meeting of this Society on the 14th inst. the President announced that the reception to be given to the delegates of the International Telegraph Conference would take place on or about the 18th June. Members of the Society and others were invited to send in any objects of interest for exhibition at the conversazione. We have commented in our Leading Article upon the principal Paper of the evening entitled "Some Historical Notes on Electric Lighting" by Lieut.-Col. Bolton. It was preceded by a communication from Mr. Wm. Ellis F.R.S., of the Royal Observatory, calling attention to the probable recurrence of magnetic disturbances when the period of maximum sun spots arrives—which according to past experience it will do about the end of this year and the beginning of next. As these magnetic activities are invariably accompanied by what the Telegraph Engineer calls Earth Currents, he suggested a more general and systematic observation of the phenomena in this and other countries; and thought that perhaps some of the new forms of Telegraphic apparatus would lend themselves more readily for this purpose than did the less delicate instruments of ten years ago. The President stated that the subject was engaging the attention of the Council; but that the Paper was a very valuable and and acceptable contribution; for which a hearty vote of thanks was accorded by the meeting.

THE CANTOR LECTURES.—Mr. W. H. Preece delivered the fifth and concluding lecture of this series on Monday, the 19th May. In our estimation this was by far the most interesting lecture of the series, and was delivered in Mr. Preece's best manner. The subject of the lecture was "Automatic and Fast Speed Telegraphy." The lecturer pointed out that the human hand, no matter how expert or how trained, must necessarily tire, and that, although it is possible to send by means of a trained operator some forty-five words per minute, this speed cannot be kept up. Machinery never tires. Hence necessity caused the human machine to be replaced by inert mechanism. In 1846, Bain, with wonderful ingenuity, contrived a fast speed instrument, the receiver of which depended upon chemical action. But Bain was before his time, and his contrivance was then shelved, as it was not wanted. He could, however, send and receive at the rate of from 1,000 to 1,100 words a minute. The modification of the Bain apparatus by American electricians was noticed, and then the lecturer proceeded to describe the Wheatstone automatic instrument, and the various improvements that had been made by Post Office officials, rendering the instrument far more effective than when it left the hands of the inventor, and providing all that was required, even at the present high-pressure rate of working. The improvements necessary for fast-speed working in the electro-magnet, by the use of relays, &c., were admirably explained by means of diagrams. The instruments were shown at work. We hope shortly to give these lectures in full, with the necessary illustrations.

THE SPHYGMOPHONE.—Benjamin Ward Richardson, M.D., LL.D., F.R.S., presented the following Note, on the Invention of a Method for making the Movements of the Pulse Audible by the Telephone, to the Royal Society, on May 14 :—"While experimenting with the audiometer, it occurred to me that I might get a secondary or telephonic sound from the movements of the pulse at the wrist. I have effected this in a very simple manner, by adding a microphone to a Pond's sphygmograph. I mount on a slip of talc a thin plate of platinum. I place the talc slip in the sphygmograph as if about to take a tracing of the pulse. I connect one terminal from a Leclanché's cell to the slip of platinum on the talc, and the second terminal from the cell to a terminal of the telephone. Then I connect the other terminal of the telephone with the metal rod of the sphygmograph which supports the talc. The instrument is now ready for use. It is placed on the pulse, in the ordinary way, and is adjusted, with the writing needle thrown back, until a good pulsating movement of the needle is secured. When the movement is in full action, the needle is thrown over to touch the platinum plate, which it traverses with each pulse movement, and completes the connexion between the telephone and the battery. The needle, in passing over the metallic plate, causes a distinct series of sounds from the telephone, which correspond with the movements of the pulse. When all is neatly adjusted, the sounds heard are three in number, one long sound and two short, corresponding to the systolic push, the arterial recoil, and the valvular check. The sounds are singular resembling the two words, 'bother it.' The sounds can be made very loud by increasing the battery power. This little instrument is not so good a recorder of the pulse as the sphygmograph, but it may be made very useful in class, for illustrating to a large number of students, at one time, the movements of the natural pulse, and the variations which occur in disease. I call the invention the sphygmophone."

ELECTROMOTIVE FORCE AND SURFACE TENSION.—During the session of the Royal Dublin Society last year Prof. W. E. Barrett read a short paper describing an experiment relating to this subject. He said that the surface of every liquid is known to be in a state of tension similar to that of a membrane stretched on all sides, and that to increase the area of the surface of a liquid requires the expenditure of work. The surface of a liquid resists extension and has a tendency to contract. Examples of this are seen in the soap bubble and the breaking up of a liquid jet. The amount of this superficial tension per unit of surface varies with the nature of the liquid and with the medium which adjoins the bounding surface of the liquid. Every two unmixable liquids in contact have a special coefficient of surface tension. The value of this coefficient may be made to vary in a remarkable degree by the electrification of the liquid surface. If mercury be in contact with dilute sulphuric acid, the surface tension of the mercury is *increased* when an electromotive force is directed from the acid to the mercury, and *decreased* when the contrary electrification is set up. To this fact certain phenomena noticed by Faraday are due. If a platinum wire be immersed in the acid, and brought very near to but not touching the mercury, the surface tension of the latter will be increased as soon as the platinum wire is made the positive electrode of a battery. The convexity of the mercury surface will accordingly become greater, and thereby it will be brought into contact with the closely adjacent electrode. But when this occurs the electric polarisation of the liquid surface ceases, as the current now passes freely through the metallic circuit of mercury and wire; the polarisation ceasing the augmented surface tension disappears, and the mercury falls back to its original flattened condition. Contact will thus be broken and electrification again occur, the mercury will once more increase in convexity, rise, make contact, lose its convexity, fall away, and hence a rapid oscillation of mercury ought to occur so long as the electrification is continued. A new form of contact-breaker is thus suggested.

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"ON AN INDUCTION-CURRENTS BALANCE, AND EXPERIMENTAL RESEARCHES MADE THEREWITH."*

BY PROFESSOR D. E. HUGHES.

Immediately upon the announcement of Arago's discovery of the influence of rotating plates of metal upon a magnetic needle (1824), and Faraday's important discovery of voltaic and magneto-induction (1831), it became evident that the induced currents, circulating in a metallic mass, might be so acted upon either by voltaic or induced currents as to bring some new light to bear on the molecular construction of metallic bodies.

The question was particularly studied by Babbage, Sir John Herschell, and by M. Dové† who constructed an induction balance, wherein two separate induction coils, each having its primary and secondary coils, were joined together in such a manner that the induced current in one coil was made to neutralise the induced current in the opposite coil, thus forming an induction balance, to which he gave the name of differential inductor. In those days physicists did not possess the exquisitely sensitive galvanometers and other means of research that we possess to-day, but sufficiently important results were obtained to prove that a vast field of research would be opened if a perfect induction balance could be found, together with a means of correctly estimating the results obtained. In experimenting with the microphone I had ample occasion to appreciate the exquisite sensitiveness of the telephone to minute induced currents. This led me to study the question of induction by aid of the telephone and microphone. The results of those researches have been already published.‡

Continuing this line of inquiry, I thought I might again attempt to investigate the molecular construction of metals and alloys, and with this object I have obtained, after numerous comparative failures, a perfect induction balance which is not only exquisitely sensitive and exact, but allows us to obtain direct comparative measures of the force or disturbances produced by the introduction of any metal or conductor.

The instrument which I have the honour to present to the Royal Society this evening, consists, 1st, of the new induction currents balance; 2nd, microphone, with a clock as a source of sound; 3rd, electric sonometer, or absolute sound measurer, a late invention of my own; 4th, a receiving telephone and three elements of Daniells' battery.

In order to have a perfect induction-currents balance suitable for physical research, all its coils, as well as the size and amount of wire, should be equal. The primary and secondary coils should be separate and not superposed. The exterior diameter of the coils presented this evening is 5½ centims., having an interior vacant circular space of 3½ centims., the depth of this flat coil or spool is 7millims.

Upon this box-wood spool are wound 100 metres of No. 32 silk-covered copper wire. I use four of such coils, formed into two pairs, the secondary coil being fixed permanently, or by means of an adjustable slide, at a distance of 5 milims. from its primary; on the second similar pair there is a fine micrometer screw, allowing me to adjust the balance to the degree of perfection required.

These two pair of coils should be placed at a distance not less than 1 metre from each other, so that no disturbing cause should exist from their proximity.

The two primary coils are joined in series to the battery, the circuit also passing through the microphone.

In place of the telephone, I have sometimes used a magnetic pendulum, the swing or the arc described indicating and measuring the forces. I am at present engaged upon a very sensitive voltameter which shall indicate and measure the force of rapid induced currents. The telephone, however, is well adapted as an indicator, but not as a measurer of the forces brought into action. For this reason I have joined to this instrument an instrument to which I have given the name of electric sonometer. This consists of three coils similar to those already described, two of which are placed horizontally at a fixed distance of forty centims. apart, and the communication with the battery is so arranged that there are similar but opposing poles in each coil; between these there is a coil which can be moved on a marked sliding scale divided into millimetres; in a line with these two opposing primary coils, the centre coil is the secondary one, and connected by means of a circuit changing key with the telephone in place of the induction balance. If this secondary coil is near either primary coil, we hear loud tones, due to its proximity. The same effect takes place if the secondary coil is near the opposing coil, except that the induced current is now in a contrary direction, as a similar pole of the primary acts now on the opposite side of the induction coil; the consequence is, that as we withdraw it from one coil approaching the other, we must pass a line of absolute zero, where no current whatever can be induced, owing to the absolute equal forces acting equally on both sides of the induction coil. This point is in the exact centre between the two coils, no matter how near or distant they may be. We thus possess a sonometer having an absolute zero of sound; each degree that it is moved is accompanied by its relative degree of increase; and this measure may be expressed in the degrees of the millimetres passed through, or by the square of the distances, in accordance with the curve of electro-magnetic action.

If we place in the coils of the induction balance a piece of metal, say copper, bismuth, or iron, we at once produce a disturbance of the balance, and it will give out sounds more or less intense on the telephone according to the mass, or, if of similar sizes, according to the molecular structure of the metal. The volume and intensity of sound is invariably the same for a similar metal. If, by means of the switching key, the telephone is instantly transferred to the sonometer, and if its coil be at zero, we should hear sounds when key is up or in connection with the induction balance, and no sounds or silence when the key is down or in connection with the sonometer. If the sonometer coil were moved through several degrees, or through more than the required amount, we should find that the sounds increase when the key is depressed; but when the coil is moved to a degree where there is abolute equality, if key is up or down, then the degree on scale should give the true value of the disturbance produced in the induction balance; and this is so exact that if we put, say a silver coin whose value is 115°, no other degree will produce equality. Once knowing, therefore, the value of any metal or alloy, it is not necessary to know in advance what the metal is, for if its equality is 115°, it is silver coin; if 52, iron; if 40, lead; if 10, bismuth; and as there is a very wide limit between each metal, the reading of the value of each is very rapid, a few seconds sufficing to give the exact sound value of any metal or alloy.

During the course of these experiments with this instrument I noticed that my own hearing powers varied very much with state of health, weather, &c., that different individuals had wide differences of hearing, and that nearly in all cases one ear was more sensitive than the other; thus whilst my degree of hearing was 10°, another might be 60° in one ear and 15° in the other.*

Dr. Richardson, F.R.S., who upon my invitation investigated this subject, became so impressed with the value of the instrument as an absolute measure of our hearing powers, and its capabilities of throwing much light upon its relation with health, that he has undertaken a series of researches which will extend over some time, and which I think, from some facts already gained, will be of great value to the medical profession. These experiments are now in his very able hands, and he will in due time announce the results to the Royal Society.

If an observer's hearing is limited to 10°, how can we hear results below this line? I should have stated that when used to measure the hearing power, we determine on a constant standard of force such as one element Daniell, but if we increase the number of elements we in same ratio increase the inductive disturbance, and thus by a large increase of force bring within our range results too feeble to be heard without its aid, the sonometer constantly, however, giving the same degree for equality as the increased force is also used on this instrument. Thus in our measurements we can entirely neglect the amount of battery, as its comparative results remain a constant.

As a rule, three Daniell elements will be found quite sufficient, and even this weak force is so exquisitely sensitive that it will find out the smallest fraction of difference in weight or structure of metals. Thus two silver coins such as a shilling, both quite new, and both apparently of the same weight, will be found to possess a difference of weight which the instrument at once indicates.

The following experiments will show its exceeding sensitiveness and its wide field of usefulness as an instrument of research.

I. If we introduce into one pair of the induction coils any conducting body, such as silver, copper, iron, &c., there are set up in these bodies electric currents which react both upon the primary and secondary coils, producing extra currents whose force will be proportional to the mass, and to its specific conducting powers. A milligramme of copper on a fine iron wire, finer than the human hair, can be loudly heard and appreciated by direct measurement, and its exact value ascertained. We can thus weigh to an almost infinitessimal degree the mass of the metal under examination; for instance, if we take two English shilling pieces fresh from the Mint, and if they are absolutely identical in form, weight, and material, they will be completely

* Abstract of a Paper read before the Royal Society, May 15, 1879.

† De la Rive, *Treatise on Electricity*, vol. i, chap. v. London, 1853.

‡ *Comptes Rendus*, December 30, 1878, and January 20, 1879; Society of Telegraph Engineers, March 12, 1879.

* To this portion of my instrument when used as a measurer of our hearing powers, we have given the name of audiometer.

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balanced by placing one each in the two separate coils, provided that for these experiments there is an adjustable resting-place in each pair of coils, so that each coin may lie exactly in the centre of the vacant space between the primary and secondary coils. If, however, these shillings are in the slightest degree worn, or have a different temperature, we at once perceive this difference, and if desired, measure it by the sonometer, or, by lifting the supposed heaviest coin at a slight distance from the fixed centre line, the amount of degrees that the heaviest coin is withdrawn will show its relative mass or weight as compared with the lightest. I have thus been able to appreciate the difference caused by simply rubbing the shilling between the fingers, or the difference of temperature by simply breathing near the coils, and in order to reduce this sensibility within reasonable limits, I have only used in the following experiments 100 metres of copper wire to each coil and 3 cells of battery.

II. The comparative disturbing value of discs of different metals, all of the same size and form of an English shilling, and measured in millimetre degrees, by the sonometer, is the following:—

Silver (chemically pure) ...	125	Iron (chemically pure)	45
Gold (ditto)	117	Copper (antimony alloy) ...	40
Silver (coin)	115	Lead	38
Aluminium	112	Antimony	35
Copper	100	Mercury	30
Zinc	80	Sulphur (iron alloy)	20
Bronze	76	Bismuth	10
Tin	74	Zinc (antimony alloy)	6
Iron (ordinary)...	52	Spongy gold (pure)	3
German silver	50	Carbon (gas)	2

These numbers do not agree entirely with any lists of electrical conductivity I have yet met with; the numbers are, however, invariably given by the sonometer, and the divergence may be due to some peculiarity of structure of the metals when formed into discs. Future investigations with this instrument will, no doubt, give more correct values than I have been able to obtain with my limited means of research.

III. It will be seen from the above, that the instrument gives very different values for different metals or alloys, consequently, we cannot obtain a balance by employing two discs of different metals, and the instrument is so sensitive to any variation in mass or matter, that it instantly detects the difference by clear loud tones on the telephone. If I place two gold sovereigns of equal weight and value, one in each coil, there is complete silence, indicating identity or equality between them; but if one of them is a false sovereign, or even gold of a different alloy, the fact is instantly detected by the electrical balance being disturbed. The instrument thus becomes a rapid and perfect coin detector, and can assay any alloy, giving instantly its electrical value. The exceeding sensitiveness of this electrical test I shall demonstrate by experiment this evening. Again, as regards coins, it resolves an almost magical problem. Thus, if a person puts one or several coins into one pair of coils, the amount or nominal value being unknown to myself, I have only to introduce into the opposite coils, different coins successively, as I should weights in a scale, and when perfect balance is announced by the silence, the amount in one box will not only be the same nominal value but of the same kind of coin.

IV. We find by direct experiment with this instrument, that the preceding results are due to electric currents, induced by the primary coil, and that it is by the reaction of these that the balance is destroyed, for, if we take an insulated spiral disc or helix of copper wire, with its terminal wires open, there is no disturbance of the balance whatever, notwithstanding that we have introduced a comparatively large amount of copper wire; but on closing the circuit, the balance is at once very powerfully disturbed.

If the spiral is a flat one, resembling a disc of metal, and circuit closed, we find that loud tones result when the spiral is placed flat, or when its wire is parallel to those on coils; but if it is held at right angles to these wires, no sound whatever is heard, and the balance remains perfect. The same thing occurs with discs of all non-magnetic metals, and a disc of metal placed perpendicular to the coils exerts no influence whatever. The contrary result takes place with a spiral of iron wire or disc of iron, the induced current circulating in the spiral is at its maximum when the spiral lies flat or parallel with the coils, giving no induced current whatever when at right angles, but the disburbance of the induction balance is more than four-fold when perpendicular to the wires of the coils, than when parallel with the same. That this result is simply due to the property of magnetic bodies of conduction of magnetism, we shall see in some following experiments.

That the currents in non-magnetic metals travel in a circle corresponding to that of the primary coil, may be seen with spongy gold. In its first extremely divided state it falls below our zero of hearing, on slightly shaking the bottle we have 2° as its value, on pressing it its value rapidly increases with the pressure, until when formed into a solid disc its value becomes 117°.

V. The instrument proves, that a very remarkable difference exists in bars of iron of the same exact form and size, but of different provenance or treated in a different manner; in point of fact, no two bars, cut off of the same rod, and treated alike, are exactly of the same value, or induce a complete balance.

Mr. Stroh, the eminent instrument maker, has kindly furnished me with numerous samples, varying in value in degrees of the sonometer from 100 to 160.

Chemically pure iron was found to be the best, but still very slightly superior to ordinary iron, which had been drawn into a wire of the required thickness. The fibrous condition thus developed being highly favourable (if softened by heat) for the conduction of magnetism. From numerous examples I select a few indicative values:—

	Softened.		Tempered.
Chemically pure iron.........	160	....	130
Forged soft iron...............	150	....	125
Wire-drawn iron................	156	....	120
Cast steel.........................	120	....	100

VI. As yet the instrument has given no indications of molecular change produced by magnetism in non-magnetic bodies, but the great change which takes place in all magnetic bodies, except hard-tempered cast steel, indicates that a molecular change of structure analogous to that of tempering takes place upon iron, steel, and nickel.

If we place a disc of iron in one of the coils, we find that the balance is destroyed, and that the iron has weakened the induction by the absorption of work done in inducing the circular currents. This can be perfectly balanced by placing a small coin or disc of silver or copper in opposite coils; but if an iron wire or rod is placed perpendicular to the coils, then increase of inductive force takes place in those coils by the conduction of induced magnetism from primary to secondary, and the iron can no longer be balanced by silver, copper, or any non-magnetic metal. The coils must be either removed farther apart, so as to reduce the increased force, or balanced by an equivalent amount of iron or magnetic conduction in opposite coils.

An interesting case of both reduction and increase of force in the same pair of coils occurs if we place a disc of iron, not in the centre of coils, but in the vacant space between the coils. We thus reduce the force by 150°. If, in addition to this, we place iron wires perpendicular and in the centre, there is increase of force, and if this increase is so proportioned as to be 150°, we immediately restore the balance, and we have here in the same coil two separate pieces of iron, each disturbing the balance and giving out loud tones, but producing no effect whatever when both are introduced at the same time, complete silence being the result.

VII. These coils prove what has already been long known, viz, that hard steel has a far less conducting power for magnetism than soft iron, although the hard steel has a far higher retaining power. This instrument demonstrates a point, which I have not yet seen remarked, that magnetism does not in itself change the conducting powers, but that it produces a molecular change of structure in iron, analogous to that of tempering; for if we balance two soft iron rods against each other, the balance being made perfect by the addition of fine iron wires on the weakest side, we find that on strongly magnetising this bar, by drawing it across a strong compound magnet, and on replacing it in its coil, it has lost 30 per cent. of its conducting power; or if, instead of magnetising, we make this iron red hot and plunge it in cold water, the loss of conducting power will be very similar —25 to 30°. If these experiments are repeated upon various degrees of iron approaching steel in character, we find that as it already possesses hardness or temper it is less and less affected by magnetism, until we arrive at hard cast steel, where magnetism no longer produces any change in its conducting powers. From this I draw the conclusion that the effect of magnetism is very similar to that of temper, and shall show under the effects of strain and torsion that magnetism produces this temper or strain perpendicular to the lines of magnetic force.

VIII. The instrument shows that a remarkable change takes place in the magnetic conducting power of iron and steel on subjecting the wire under examination to a longitudinal strain; for if we pass an iron wire through the centre of both coils, half a millimetre diameter and twenty centims. or more in length, so arranged by a winding key that we can apply a strain to this wire, we find a magnetic conducting value, unstrained, of 100, but on applying a slight strain its value rapidly increases, being more than double at its breaking point. If during this strain we strike the wire, we hear its musical tone, and no matter how much we may wind or unwind it, provided we do not pass its limits of elasticity and similar wire is used, that the same musical tone

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will invariably give the same magnetic value. Thus the note A, or 435 complete vibrations per second, gave always the magnetic value of 160, or 60 per cent. increase of power over the unstrained wire. If whilst this wire is strained, giving the value 160, we magnetise it by drawing over it a strong compound magnet, the note remains the same, showing no difference of tension, but its magnetic value has fallen 80°, being now 80 instead of 160; and this wire can never again be brought by strain up to its previous high conducting powers. Now as we have seen, that magnetism produces no change in hard tempered steel, but that it does so in soft iron very analogous to that of temper, and as the effect of strain would be also to harden the fibres by bringing them all parallel to the line of mechanical strain; and as this improves its conducting power, while magnetism instantly destroys all the benefits of the longitudinal mechanical strain, we can only draw the conclusion that magnetism produces a strain analogous to temper, but contrary to that of the longitudinal mechanical strain; in other words, that the magnetic strain is produced perpendicularly to its lines of force.

This view is sustained by the effects of torsion; for if, in place of straining the wire, it is twisted, instead of increasing, it rapidly decreases in magnetic conductive value, each turn or twist decreasing its power of conduction in a remarkable constant line of decrease. At eighty turns of this wire there was a decrease of 65 per cent.; at eighty-five turns the wire broke, and on testing it to see if magnetism had any decreasing effect on it, I found that it produced no change whatever; but this twisted soft iron wire had now remarkable permanent retaining powers of magnetism, being superior to tempered cast steel.

Again, if we take three similar pieces of soft iron wire, leave the first for comparison in its natural condition, strain the second by a longitudinal strain until it is broken, and twist the third by a torsion-key until it also is broken, we find on magnetising equally these three wires, and allowing ten minutes repose, that the first or untouched wires has a retaining power of magnetism of 100, the second only of eighty, and the third, or twisted wire, of 300. I hope by the light thus given soon to be able to produce a magnet whose force shall be greatly in excess of what we have hitherto possessed; our difficulty at present being that in order to temper steel, we must heat it to redness, and this allows the molecules to rearrange themselves contrary to the object we have in view.

IX. There is a marked difference of the rapidity of action between all metals, silver having an intense rapidity of action. The induced currents from hard steel or from iron strongly magnetised are much more rapid than those from pure soft iron; the tones are at once recognised, the iron giving out a dull, heavy smothered tone, whilst hard steel has tones exceedingly sharp. If we desire to balance iron, we can only balance it by a solid mass equal to the iron to be balanced. No amount of fine wires of iron can balance this mass, as the time of discharge of these wires is much quicker than that of a larger mass of iron. Hard steel, however, can be easily balanced not only by steel but by fine iron wires, and the degree of the fineness of these wires required to produce a balance gives a very fair estimate of the proportionate time of discharge. The rapidity of discharge has no direct relation with its electrical conductivity, for copper is much slower than zinc, and they are both superior to iron.

X. The instrument shows a marked difference in all metals, if subjected to different temperatures. The value is reduced in non-magnetic metals, and this we should expect from the known influence of temperature on the electrical conductivity; but in the case of iron, steel, and nickel (as it has already been remarked by many), the contrary takes place, namely, a far higher degree of magnetic conductivity. A bar of soft iron, whose value at the temperature of the room, 20° C., was 160, became on heating it to 200° C. 300, that is to say, its value was nearly doubled. A bar of pure nickel, whose value at 20° was 150, became on heating it to 200°, 320; thus, in the case of nickel, its value for magnetic conductivity was more than doubled, and at this heat it surpassed the chemically pure iron at the same heat, giving a magnetic value of 320 against 300 for the iron, but at the normal temperature of 20° the iron had more magnetic power of conduction than nickel. Heating nickel by simply plunging it into boiling water increased its force from 150 to 250, plunging this same bar into ordinary cold water reduced its value to 130; thus the mere difference of the normal temperature of the air in the room and water which had been in this room some hours produced 20° of difference. In fact, I found that the radiant heat from the hand would raise the magnetic value several degrees, and thus nickel may be regarded as a magnetic thermometer far more sensitive than the ordinary mercurial Centigrade.

The instrument also measures the electrical resistance of wires or fluids. In order to make it do this we have only to place the resistance to be measured across the two wires of one induction coil and on the other known resistance units. In this way we can produce a perfect balance, for it then becomes an induction bridge, the results and modes of testing of which are somewhat similar to Wheatstone's bridge.

It measures also the electrostatic capacity of Leyden jars or condensers, and is sufficiently sensitive to appreciate and measure a surface of tinfoil not larger than four inches square, the condenser being simply placed between the wires of one pair of coils, and the disturbance produced being measured on the sonometer.

I could cite many more interesting experiments in other branches of physical research for which this instrument offers a wide field of observation; but my object this evening is neither to broach new theories nor to correlate at present the results obtained with views already advanced by Ampère and others.

My only desire has been and is to show the wide field of research the instrument opens to physical inquirers. I trust that in more able hands it may serve to elucidate many physical phenomena.

SUBMARINE TELEGRAPHY.

BY A. JAMIESON, C.E.

Lectures on "Submarine Telegraphy" are from time to time delivered to the Eastern Telegraph Company's staff at Porthcurno and Malta, where young men are specially trained for the company's service.

We make the following abstract of lectures recently delivered at Malta by the company's electrician, Mr. Jamieson, C.E., and propose to publish in full some of those more especially devoted to submarine telegraphy, such as the "Rise and Progress of Submarine Telegraphy," the "Necessary Instrumental Requirements of a Submarine Telegraph Office," "Batteries Employed, and Precautions to be Adopted in Keeping Them in Good Order," "Sir W. Thomson's Mirror Galvanometer, Siphon Recorder," &c.

In the first lecture Mr. Jamieson reviewed generally the history of electrical science, and showed that as far as it was connected with telegraphy, it might naturally be divided into three stages, and gave practical examples of different discoveries.

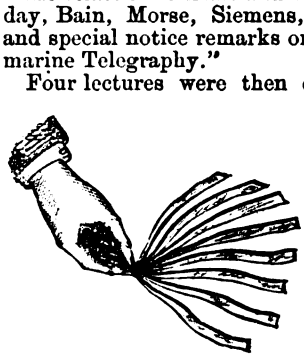
1. The early observations of electrical phenomena: Under this head he exhibited the discovery by Thales in 600 B.C. that rubbed amber possesses the property of attracting light bodies, and those of Dr. Gilbert in 1600 A.D. that spars, gems, fossils, &c., possess like properties under similar conditions, and mentioned the phenomena observed by Boyle, Von Guericke, Wall, Newton, Stephen Gray, Franklin, and others.

2. Suggestions and experiments as to the applicability of electricity to the transmission of intelligence and the discovery of galvanic electricity: The lecture referred to the suggestions of Joseph Granville, Charles Marshall, and the experiments of Galvani, Volta, Soemmering, Sir Francis Ronalds, &c.

3. The practical application of electricity and magnetism in connection with various forms of lines and instruments.

He related the trials and success of Cooke, Wheatstone, Faraday, Bain, Morse, Siemens, Thomson, &c., but left for future and special notice remarks on the rise and progress of "Submarine Telegraphy."

Four lectures were then devoted to frictional or static electricity, wherein he exhibited and described the properties of electrics and non-electrics or insulators and conductors, and classified different materials, according to their power of resisting the passage of electricity. He explained the laws of electric repulsions and attractions, and the terms positive and negative electricity, exhibiting Tyndall's well-known experiment of a dry sheet of paper rubbed and slit into strips —presenting then an appearance like the hair of Medusa when lifted by the hand into the air.



He also gave a large number of experiments on electrostatic induction similar to those we lately published in *The Electrician*, which were delivered by Mr. Gordon at the Royal Institution; and described in detail Planta's frictional electrical machine, as well as the electrophorus and Leyden jar. He exhibited the effect of electric light in vacuo by the assistance of an air pump and a series of vacuum tubes. He devoted some little time to atmospheric electricity and lightning, with its causes and effects, and exhibited by aid of an electric stool the well-known experiment of the return stroke.

Two lectures were spent on the general principles of magnetism and electro-magnetism, and the laws regulating magnetic, electro-magnetic, and magneto-electric induction, to prepare the staff for a detailed explanation of Sir William Thomson's mirror galvanometer and siphon; and a couple of lectures on electrical units of measurement employment in telegraphy.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, Strand, London, W.C.

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THE HISTORY OF ELECTRIC LIGHTING.

The spring session of the Society of Telegraph Engineers was brought to a most satisfactory conclusion on Wednesday evening, the 14th instant. If the gathering was not as numerous as on many former occasions, or the proceedings of such startling interest, the work that was brought to light for the first time will, if we mistake not, lend a far more enduring reputation to the Society. It was known that Lieut.-Col. Bolton, the Honorary Secretary, had long been preparing a paper relating to the History of Electric Lighting; and on the evening in question an outline of the results of his labours was made public. It would be impossible to reproduce in any useful shape a report of what transpired ; all that we can hope to do is to enlist our readers' interest in anticipation of the paper itself ; and we shall do this with the greatest confidence, as it contained abundant evidence not only of painstaking industry of a quite exceptional kind, but of intelligent discrimination in selecting the materials brought together. Of the former it is sufficient to mention that every patent, and almost every paper published on the subject of Electric Lighting, and anything bearing thereon, appeared to have been ransacked, the details epitomised, the dates collated, and the leading ideas classified. The examination extended over a period of fifty years or more, and was brought down as near as may be to present date. We are afraid to estimate the amount of labour which this undertaking must have involved ; and, if the information thus obtained is as thoroughly reliable as it is voluminous, the next number of the Society's Journal will be one of the most valuable of the series.

Had the public press, or even the professional electrician been at all well-read in the history of past attempts at Electric Lighting, there would have been no panic in gas shares last year, and there would have been far less money uselessly squandered in patenting ideas which had many times been tried and come to nothing before. For fifteen years past there has been nothing deserving to be called new in this field of study ; the only thing that is novel being the humour of the public, which has unexpectedly taken a fancy for an unfamiliar light. Possessed with these ideas, Colonel Bolton thought he could render some service to the public, and also to the profession, by gathering together all the conceptions, aspirations, successes, and failures, of the past for the guidance of those who are investigating, and for warning to those who are pecuniarily concerned in the final outcome. How few are the people who trouble to search for these facts is shown by the number of duplicate patents that are applied for and never proceeded with; and how difficult it is to make the search may be imagined from the fact that the Abstracts of Patents of the class to which we are referring are only carried down to the year 1866. Such a long arrears, for which the Patent Office is alone responsible, is obviously a discouragement to all research whatsoever; and it is not surprising that this Branch of the Government service has its reward for *not* doing its work properly. The Patent Office does in fact profit by the inventor's ignorance, which it takes no pains to enlighten. Colonel Bolton's exhaustive paper will supply what is needed in this relation, and although it is too much to expect that every enthusiast will have the courage to face the rude shock that these revelations would administer, the more robust fibre of the Telegraph Engineer may be trusted to examine and profit by them. He has in fact the future of the Electric Light in his own hands. He now knows all that has been done for it, all that was valuable, all that was worthless, and a few things that may be worth trying again.

Thus the ground is cleared, and a fair start can be made by anyone who has a mind to proceed. But we are bound to say that from this point of view Colonel Bolton's paper was not calculated to inspire confidence. We are often told that there is nothing new under the sun—a saying as false as it is cynical. But if ever a man was justified in uttering it Colonel Bolton must be that man. The most alluring—or at all events the most loudly-trumpeted—discoveries of the last twelve months, are, he finds, as old as any cab horse who is still permitted to live. Looking at the pictures which had been carefully prepared and exhibited for our edification, we took them to be portraits of promising infants just recently born ; but Colonel Bolton had remorselessly certified their age, and what we fondly imagined at first sight were living offspring of the Edisons of the period were for the most part but the abortions of a bygone age. Of machines for feeding the Electric Light as well as of the

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Lights and Lamps, the same story had to be told. In 1840 Smith invented so and so; Brown did the same in 1860; and this is precisely what Jones and Robinson have done again in 1879. We do not care to particularise more specifically; because the originality of many living men was inferentially called in question, and they may have something to say for themselves when the paper is published. But we cannot refrain from according honourable mention to the names of Staite, and Pearce, and Binks, and De Moleyns, who between the years 1840 and 1850 seem to have anticipated everything that has been done or attempted in quite recent years. We say everything, for not an idea or a device that has lately been suggested, from the Jablochkoff candle to the platinum iridium lamp of Edison—not excepting the ingenious contrivance of Messrs. Houston and Wright, but seems to have found its way to the Patent Office, if no farther, very, very, many years ago. The makers of magneto generating machines fare perhaps a little better. Here the stages of progress are more marked, and are generally, though not always, the result of some discovery that is absolutely new. It is in this direction, therefore, that the prospect seems most inviting. But judging by past experience it is to scientific investigation rather than to uninformed ingenuity that we must look for any great improvement in the capabilities of Electrical Illumination. Professor Ayrton had charge of the Paper—the author himself being incapacitated through hoarseness—and as the learned professor was thoroughly familiar with its contents, having had some considerable hand in preparing it, his rendering was very free indeed, so that at times his hearers could not distinguish between what was text and what annotation. On the whole, however, an unmistakable impression was left on their minds that Colonel Bolton was not the first person who had curiously scanned the archives of the Patent Office, and that the motive may not always have been as disinterested as was his. For this reason alone the publicity which his paper will now ensure for all the antecedent facts cannot fail to be wholesome and sulutary at the present time. Moreover there is much in them that is instructive and suggestive; and if anything really new can be accomplished it will probably date from the publication of Colonel Bolton's Historical Notes.

CORRESPONDENCE.

IS "AN ELECTRICAL SOCIETY WANTED"?

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I was rather surprised that the article in your journal of March 22 has met with such little response.

The letter from Mr. Latimer Clark which appeared in yours of the 10th inst. shows that the exclusiveness, so far as the title of the Telegraph Society would lead one to believe in, deters many from becoming members.

Mr. Latimer Clark's letter should be read carefully in order to show the expediency of so modifying the title of the Telegraph Society that any subject of electrical interest may be fairly considered to come within the scope of the society's business, for it is evident that if an electrical science society were called into existence it would materially weaken the hold which the Society of Telegraph Engineers possesses as representing electrical science.

On the other hand, is the Society of Telegraph Engineers likely to suffer by ceasing to confer the status which its title implies? In the society's bye-laws, just issued, and which, I believe, have not been altered, is the following relating to membership:—

"Every member shall have been previously elected as an associate of the society, and shall come within one of the following conditions:—

"(a) He shall have been regularly educated as a telegraph engineer, according to the usual routine of pupilage, and have had subsequent employment for at least five years in responsible situations.

"(b) Or he shall have practised on his own account in the profession of a telegraph engineer for at least two years, and have acquired a degree of eminence in the same.

"(c) Or he shall be so intimately associated with the science of electricity, or the progress of telegraphy that the council consider his admission to membership would conduce to the interests of the society."

It would scarcely do to insert after this that membership must not be regarded as implying any claim to professional qualification, and I can quite understand that those who have been trained as engineers, or who come under either of these divisions, dislike being bracketed with those who have had no training professionally or in any other way.

Some time ago a discussion was raised as to the admission of females to membership, and it is difficult to understand why, since no clause exists as to wearing breeches, females are not allowed to enjoy the privileges of their male *confrères*. It cannot be argued that the high class papers are beyond their comprehension, or that the gravity of the discussions would be impaired "because of the ladies."

I would suggest, if it is desirable to retain the title of the society as it now stands, that "sections" like those adopted by the Society of Arts may be made to deal with electrical and other subjects which do not fall fairly within the province of telegraphy.

Educational papers, or papers of less scientific interest, may be read, to which the weaker sex may be admitted. In this way we might have papers once a week all the year round, instead of fortnightly for six months.

With respect to the admission of females as members or associates, or, at least, to the meetings of the society, I think that, as the telegraph department is so strongly represented, it is a great injustice to the unrepresented sex that gender forbids the handling of shunts and logarithms. I know of no more worthy cause for those who advocate women's rights than to agitate for their employment in the higher branches of the service to which they have proved themselves well adapted.

I think that it would be very undesirable to have another scientific society dealing with electrical matters. The Society of Telegraph Engineers has shown its usefulness in the bringing together many interested in the profession of telegraphy as engineers, electricians and operators, manufacturers of telegraph material and plant, instruments, &c., that there is much for the founders of the society to feel proud of. But there is a point which strikes me as being worth noting when we deal with the practical results of the society's working. How many of the members are *bonâ fide* telegraph engineers, or who even possess a fair amount of knowledge to render them competent to deal with the engineering matters relating to telegraphy, and how many thoroughly engineering papers have been discussed by the society? An answer to such queries must convince anyone that the title of the society imperfectly conveys what its actual constitution is.

A short time ago Mr. Jamieson read a very interesting paper before the Society on "Grappling Cables," &c., and I think no one who was present, considering the importance of the subject, could consider the discussion which followed as doing much credit to the society as a body of engineers. With the exception of Sir Charles Bright's remarks, engineering, as an element of discussion, was conspicuous by its absence.*

It will be well to read the excellent address of C. W. Siemens, Esq., on the first meeting of the society. The large number of the society's publications on hand which you referred to some time ago I take as a clear proof that the society has become "specialists," or "fractional quantities of scientific men." Why cannot the society's journal be the means of conveying to the meteorologist, the account of magnetic changes and other cosmical phenomena connected with electricity.

In the chemical division of the subject we have electrometallurgy, a science extensively applied to the coating of metals, and the production of works of art, but a science almost untrodden by the electrician. The application of electricity to metallurgical operations, and the utilisation of currents for effecting the production of chemical compounds, are fields full of promise. The use of electricity as a therapeutic agent, and many other applications may be named, which by no stretch of reasoning

* Is it possible to have a real discussion when a paper is rapidly read before a mixed audience?—*i.e.*, an audience, some members of which are acquainted with the subject, and some have no conception of it. At present a favoured few are seen with proof slips of the paper in their hands; but if you desire a real discussion, any member should be able to get such a slip. Other societies, some three or four days previous to the meeting, send to gentlemen likely to take part in the discussion 100 or 150 copies of the paper to be read, and hence at such societies we get what is required—real discussion—and a large and valuable supplementation to the paper.—[Ed. *E.*]

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could be considered subjects for discussion by telegraph engineers, but would be legitimate matters for an electrical society to take up.

It may probably be difficult to define the limits as to what may be considered an electrical paper, but this should be an advantage rather than otherwise. Telegraph engineering admits of being easily defined, but to keep within its limits electric lighting and the construction of machines for this or electro-plating purposes are not admissible. It is easy to see that telegraph engineers who have been thoroughly trained as such do not care to be catalogued with operators and electric bell makers in a way to convey an equal status professionally. If there is sufficient interest felt in telegraph engineering to maintain a society in a prosperous condition, we can afford to discard professional jealousy, but does a society serve its purpose to an advantage by retaining a title which keeps away many who are well entitled to its membership, and could add probably to its usefulness and popularity, if a slight modification in its title would enable it to deal with the ramifications of applied electricity, whilst at the same time it would not exclude the purely scientific questions of electricity, or other branches of science such as hydrography and geology, navigation and natural history, so far as they ought to concern the telegraph engineer? I think you have done good service to the Society of Telegraph Engineers by your article. A man who has practised telegraphy all his lifetime is not easily persuaded that there are other equally important uses for electricity.

I would suggest that the society retain its present title as near as possible, and arrange its business so that by means of "sections" any electrical subject could be dealt with; we should then avoid "professional susceptibilities," and could discuss such papers as the preparation of frog broth, or the influence of strychnia on the galvanoscopic action of the frog.—Yours, &c.,

THOMAS T. P. BRUCE WARREN.

Silvertown, Essex.

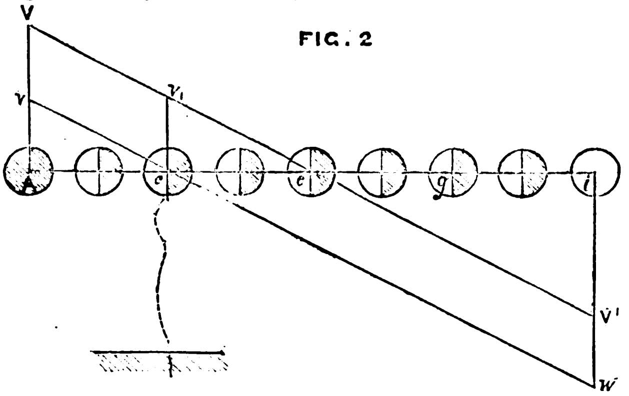
THE ENERGY STORED UP IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I will now, with your permission, conclude my unfinished letter of last week.

Let A and f represent two conductors charged from the poles of a source, and let c, c, y, &c., represent polarised dielectric molecules between them. Let us, as before, consider only the direct inductive circuit—virtually, in this case, from one pole of the source to A, from A to t, and from t to the other pole of the source. The normal distribution of tensions, or potentials, will be represented by the line V V_1.

FIG. 2



Now let a wire, pointed or tipped with flame, be brought into contact with the polarised dielectric particle represented by c. This particle will *not* lose the inducteous charge normal to it in the direct circuit, it will *not* obtain an induced charge opposite in sign to that upon A, and it will still remain polarised. Yet the distribution of tensions will become altered; being now represented by the line v w Nevertheless the total quantity of energy stored up in the (direct) circuit will remain unaltered.

But the original potential at the point c was unity; and this, apparently, cannot be expressed as

$$e_1 = \frac{2w_1}{Q},$$

since Q does not pass to earth.

The exception or contradiction to the law I have formulated is however, I claim, only apparent. There is in nature no inductive circuit without *branch circuits* as well as a direct or main circuit. A direct circuit strictly without such branch circuits would *exhibit no tension*, would give no electrometric indication. Will Dr. Lodge state that it would exhibit *potential*? There is necessarily a branch circuit between c and earth, as well as a direct circuit between c and t. And a very minute quantity (q) of electricity, accumulated in this branch circuit *does* pass from c when this polarised particle is brought into communication with earth. Let $q = \frac{Q}{n}$, then, if w_1 be the work stored up in q, $w_1 = \frac{w}{n}$. Thus the original tension or potential at c will be expressed by

$$c_1 = \frac{2w_1}{q} = \frac{2w}{Q}.$$

In regard to Dr. Lodge's appeal. I cannot find I have anywhere stated that "the word *tension* has no real and useful meaning apart from *potential*." On the contrary, I believe that it *has* such a meaning. I much object, however, like the French electricians, to its being appropriated for use in a novel signification—considering that for many years I used it in another sense, that of *potential*. The latter term refers to a development—theoretically, it may be, a very important development—of the original idea of tension. But the practical man means by "potential" precisely what he used to mean by "tension;" although as a rule the *definition* of the former term is *quite unintelligible* to him. It is to the use of the term "potential" in practice, not in theory, that I object; and I certainly cannot yet perceive that the objection is uncalled for.—Yours, &c.,

DESMOND G. FITZGERALD

POTENTIAL AND OTHER MATTERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps you will be good enough to allow me to reply on several subjects in one letter, which I hope will not be a very long one.

First, I have to express my regret that any sentence of mine should have had the appearance of being an imputation of disingenuousness or of anything else in the slightest degree offensive. I had nothing of the sort in my mind when I wrote, and though on reading the paragraph on p. 298 again I perceive that there is not altogether a pleasant tone about it, yet I can say most truly that it was unintentional and that I was not conscious of it till Mr. FitzGerald's letter on p. 307 directed my attention to it. I had, however, certainly the impression that Mr. FitzGerald was expending ingenuity in supporting a statement which did not really enter into his system, but which he had recently made for the first time without any very real evidence in his own mind one way or the other on the subject, and which therefore it was possible a few days more consideration might easily show the incorrectness of. In this idea I find now that I was mistaken, and that Mr. FitzGerald really does believe that points in a dielectric ordinarily possess a considerable charge of electricity. Here then, probably for the first time, we appear to differ as to a matter of absolute fact. But I am not sure even now whether it is not only a question of nomenclature, because Mr. FitzGerald has not defined what he means by "charge." He uses terms not in the ordinary vocabulary without defining them, notably "*inductive resistance*" and "*inducteous charge*;" and though I imagine that the former term merely means the reciprocal of inductive capacity, I don't think I have any idea what the other means.

In no meaning of the word that I can imagine, can I conceive myself as saying that a point in an ordinary homogeneous polarised dielectric possesses a *charge*; and I felt this so strongly when writing my letter last week that I was unable to believe that Mr. FitzGerald really meant to assert that it does. I find now that he did mean to assert it, and I can only suppose that he attaches a different meaning to the word than that which most people attach to it; a meaning which he will find stated in Mr. Cumming's articles in your two last issues, with all of which, as far as I have read them, I agree.

In his two diagrams and accompanying explanation Mr. FitzGerald seems rather to set the question before himself, than to arrive at any very definite conclusion; and I scarcely think that my entering into a full discussion on the subject would serve any useful purpose. But I am interested in seeing those diagrams because I perceive that his views on the nature of dielectric polarisation differ considerably from my own. I must confess to a certain feeling of repugnance towards circles shaded on one half and plain on the other; for I believe that they tend to obscure the real facts far more than they tend to elucidate them—far more indeed than the mathematical symbols and terminology to which several of your correspondents so much object.

My own views on the subjects of dielectric polarisation, induced charge, contact electricity, and other matters, (derived from a careful study of Faraday and Clerk Maxwell) happen to be rather clear and distinct—they may be right, or they may be wrong, that is a question at present of opinion but ultimately of experimental fact—but they are certainly clear in my own mind, which

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is something. I have been thinking lately that it might be worth while to state and illustrate them as concisely as convenient in an article or two on the subject; and as soon as I can find time to put them into proper shape I shall, with your permission, hope to do so.* And then, if Mr. FitzGerald and Mr. Sprague, for both of whom I entertain the greatest respect, or if any other of your readers, think fit to honour me with attacks and criticisms, I shall be very pleased to sustain them; especially shall I be glad to reconsider views founded mainly on the mathematical theory of electricity as developed by Clerk Maxwell, in the light of their profound experimental acquaintance with the subject.

But I venture to think that both these gentlemen will find the notions far more in harmony with many of their own than they at present think likely, and they will find that one can get on very well without discarding the expression "potential of a surface or point, or difference of potential between two surfaces;" also without "recognising that these are simply expression of the energy charged upon a definite field of force" (whatever that may mean); and finally without "throwing infinity into the waste basket of science;" which last would be an unwise proceeding, because there could be but little room left in the said basket for "the vitreous and resinous fluids," for "dissimilated electricity," and for other little matters, which would doubtless be better stowed safely away there as soon as possible.—Yours, &c.,

OLIVER J. LODGE.

POTENTIAL AND INFINITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Sprague, who, by the way, will find if he refers to my letter again that I called him neither a paradoxist nor a circle-squarer, demands an answer to a certain question, viz., how we are to conceive a battery with its poles connected to two bodies, one here and the other at infinity. Surely nothing can be easier; but if he chooses to imagine that he cannot conceive such a thing then I am afraid I cannot help him. I expect, however, that what Mr. Sprague really wishes me to admit is that such an arrangement is experimentally impracticable. Well of course it is, but it does not follow that it is inconceivable.

Writing on the same subject in a previous letter, he said that he *agreed* with Prof. Maxwell's humorous remark that "this point of reference (infinity) is not conveniently accessible," as if he expected that I or some one else would *disagree* with it, and would assert that infinity was a perfectly accessible locality if only you set the right way about getting there. Well, I don't know what cutting one's throat might do for one, but otherwise I assure him I have no notions on the subject.—Yours, &c.,

OLIVER J. LODGE.

ON SOME PROBLEMS IN CHARGING AND DISCHARGING WIRES ATTACHED TO AN INSULATED BATTERY.

BY F. C. WEBB, M.I.C.E.

If wires having considerable inductive capacity, such as lengths of gutta percha-covered wire immersed in water, be attached to the two poles of an insulated battery, the ends of the wires not attached to the battery being also insulated, some interesting points may be noticed as regards their charges when the lengths are varied, as also when the charging and discharging is effected in different ways.

If the wires are of the same pattern throughout, their capacity will be proportional to their length—the quantity of charge will be proportional to the length multiplied by the potential between each wire and earth. Now, the two conditions to be satisfied in the charging are, first, that the quantities in the two wires shall be equal and opposite, and, secondly, that the algebraic difference of the potentials between the wires and earth shall be always equal to the electromotive force of the battery, or, putting

T potential in and l length or capacity of wire A,

$-t$ potential in and L length or capacity of wire B.

Then $T-(-t)=E$; or $T+t=E$, and $Tl=tL$. From which we get—

$$\frac{EL}{l+L}=T, \qquad E-T=t.$$

Thus, if $E=10$, $l=4$, and $L=8$, we have

$$\frac{10\times 8}{4+8}=\frac{80}{12}=\ 6{\cdot}6=T, \text{ and}$$

$$10-6{\cdot}6=\ 3{\cdot}3=t,$$

$$Lt=Q=26{\cdot}4=\text{Quantity of Negative in L.}$$

$$lT=Q_{\prime}=26{\cdot}4=\text{Quantity of Positive in } l.$$

It will be seen that, if one wire is constantly increased, the quantity in each will constantly approach, but never equal, what the wire of least capacity of the two would receive if charged by the battery, with the other pole to earth. Also, that as one wire is increased, the potential of it decreases whilst that of the other rises, constantly approaching the full electromotive force of the battery.

If two equal wires, A and B, are thus charged to half opposite potential, and then one, B, discharged to earth, and then replaced, it will be found that it will now charge to quarter potential, whilst the other will rise to three-quarters; and if B be again discharged and replaced, it will charge to one-eighth, whilst A will rise to seven-eighths, and so on, A constantly approaching to full charge, and B becoming less and less.

If one wire is charged from one pole with other pole to earth so as to charge it to full potential of electromotive force of battery above earth, then if the pole connected to earth is disconnected and brought into contact with another wire no charge will be obtained in that wire.

Charging now B from positive pole, with negative pole to earth, and then discharging, we get a charge, say, C.

If, now, A be charged from positive pole, with negative to earth, and then reversing battery, thus connecting A to negative pole, we touch the positive pole to B, we shall get the same charge C in B as we did when charging it with the negative pole connected to earth, notwithstanding that the negative pole is now connected to a body charged to a positive potential of E above the earth.

Again, charging the two wires from opposite poles and discharging each, and noticing the discharge C from each, and then charging in the same way and discharging the wires to one another, we get precisely the same result as discharging from one wire to earth. Thus the discharge of negative charge to positive charge is the same as from either wire to earth. Notwithstanding that between the charges there is a difference of potential equal to E, whereas between either wire and earth there is a difference of only ½ E. Or, looking at it from another point of view, when we have discharged one wire alone we have still the same quantity left in the other as that already discharged, so that one would think that discharging the two at once would produce double the effect of the one separately. One way of looking at the problem is, that as although between the two wires there is a difference of potential of E (instead of ½ E in the other case between each wire and earth), yet it has to act through double the inductive resistance, the charge in one wire neutralising the charge in the other, whilst the charges on the outside of each wire recombine through the earth. Thus the inductive circuit is composed of the coatings of the two wires and is double what it is in the case of discharging one wire to earth.

ON THE DIVISIBILITY OF THE ELECTRIC LIGHT.

BY W. J. WILSON, F.C.S., M.S.T.E.*

The conditions under which the electric light is indefinitely divisible appear to be simple enough, but yet do not seem to be generally recognised.

Suppose that we have a voltaic battery, the resistance of which together with that of all necessary connecting wires, &c., is r. Let this resistance be supposed to remain constant throughout our investigation. The first problem is:—If we insert a platinum (or other) wire into this circuit what must be the resistance of this wire in order that as much heat as possible shall be developed in it in unit time? Let us call this resistance P.

According to Joule's law the quantity of heat developed in a conductor in unit time is proportional to the resistance of the conductor and to the square of the current strength. Hence the heat in the wire will be proportional to C^2P. Ohm's law tells us that C is $=\dfrac{E}{R}$ or $\dfrac{E}{r+P}$. Therefore C^2 is the same as $\dfrac{E^2}{(r+P)^2}$, and C^2P, which represents the heat in the wire, may be expressed as $\dfrac{E^2}{(r+P)^2}P$. The value of this fraction will be greatest when P is equal to r; hence, as is well known, the resistance of the wire should be equal to that of the rest of the circuit.

Recognition of this fact will simplify matters, inasmuch as it enables us at once to dismiss any proposed system in which this relation is violated as necessarily unprofitable.

As far as the *quantity of heat* developed in it is concerned, the *mass* of the wire may be anything; for the resistance P may be represented by a wire of any length and proportional diameter. The *temperature* of the wire will, however, be greater the smaller the mass of metal, and, in order to obtain the greatest amount of *light* it is obvious that the mass should be diminished until

[We shall be very pleased to publish the articles in question.—ED. *E*.]

* Read before the Physical Society, 10th May, 1879.

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the temperature approaches, as nearly as may be, the fusing point of the metal.

Suppose that we have in this way obtained the greatest possible amount of light from an incandescent wire inserted into the given circuit and that this light is, say, equal to 1,000 candles. The next problem is :—Can we substitute for this single wire ten others each giving a light of 100 candles or 1,000 wires each of one candle power and so on?

It is clear from the first part of our investigation that the combined resistances of whatever wires we substitute for the single wire must be equal to its resistance P; otherwise we shall not get in them so much heat. Bearing this in mind, it has been said that we may use instead of the one wire, say sixteen other similar ones arranged in four circuits of four lights each; the four circuits being joined in multiple arc. The resistance of each circuit being four times that of one wire, the resistance of the combined circuits would be one-fourth of this amount or the same as that of one wire. Here there would be the same quantity of heat developed in the sixteen wires that was previously confined to one. Similarly the heat might be distributed over four wires in two circuits, nine wires in three circuits, 100 wires in ten circuits, and so on, the number of wires increasing with the square of the number of circuits.

The defect in any arrangement of this kind is that while the quantity of heat is kept constant, the mass heated is largely increased and the temperature consequently rapidly diminished; an objection which must be fatal, inasmuch as the ratio between the luminous and non-luminous radiation of any incandescent body rapidly decreases with any reduction of temperature. It is indeed obvious that when the mass is increased to a certain amount no light at all will be emitted, although the quantity of heat produced may be the same.

Let us now return to our single incandescent platinum wire, emitting light equal to 1,000 candles. Suppose that we substitute for it ten other wires, each being of the same length and one-tenth sectional area of the original wire, the ten being joined in multiple arc. The arrangement is in fact equivalent to splitting the one wire longitudinally into ten parts. Then, the united resistance being the same as that of the original wire, the strength of the current will not be altered, and the quantity of heat developed in the ten wires will be that previously produced in the one. The mass being also the same, the temperature and quantity of light will be unaltered, but the latter will be divided into ten parts; that is, we shall have ten 100 candle lights instead of the one 1,000 candle.

It is evident that in a similar manner we might use 100, 1,000, or any other number of wires to thus subdivide the light without loss, provided only that the length of each wire and the united sectional area of all should be equal to that of the original wire.

In order to avoid confusion, one important consideration has hitherto been omitted which must now be taken into account. It is that although the mass of metal and the quantity of heat developed in it in unit time may remain constant, the thinner wires will *lose* heat more rapidly by radiation and convection, chiefly the latter, and so their temperature and light will be diminished. The objection, however, is only apparent; for all that is necessary to regain the required temperature, or to obtain even a higher one, is to still further reduce the mass of each wire, diminishing its diameter and proportionally shortening its length so as to keep its resistance the same. In this way any increased rate of loss of heat may be easily compensated.

Returning once more to our single platinum wire, we might produce from it a number of smaller lights in another way. Instead of slitting the wire longitudinally we might cut it transversely into a number of shorter pieces, uniting all these by connecting wires into one circuit. Here, except in so far as the wires would lose more heat by conduction to the connections, the sum of the lights would be equal to that of the one.

There appear to be two chief objections to a system of many lights in the same circuit. One is that any accident occurring to one is liable to affect all the others; but this lies within the scope of invention to remedy: the other is that the greater the number of lights the greater will have to be the resistances r and P in order to allow of the division. This involves the use of a greater electromotive force and consequently greater difficulty in insulation, this latter fact being of great practical moment.

It will be easily seen that in order to allow of division on the multiple arc system the resistances r and P should be as *small* as possible, on the single circuit system as *large* as possible; consequently by a combination of the two it seems probable that a practical arrangement to suit any given circumstances may be made without difficulty.

It would seem therefore that, in theory at least, subdivision of the light without loss *is* possible to any extent, if the following conditions can be fulfilled:—

1. That the combined resistances of all the incandescent substances used be so arranged as to be always equal to that of the rest of the circuit.

2. That the mass of each incandescent body be reduced as far as will suffice to raise its temperature to the highest degree which its material and construction will safely allow.

Hence the practical problem is reduced to that of finding either a new material or a method of using known materials so that, being heated by an electric current, they may be capable of indefinite subdivision into small masses and also capable of standing as high a temperature as possible. This is clearly within the province of inventors.

An incandescent *wire* has been spoken of because it affords the easiest means of illustrating the principle of division, but the electric "arc" is, after all, only an incandescent mass, and falls under the same law. The present superiority of the arc to a metal wire will be seen to be due to two of the conditions pointed out above; one, that the material used, carbon, will stand being heated to a much higher temperature, and hence the ratio of luminous to non-luminous radiation is greater for the same quantity of heat; the other, that this high temperature is easily attainable owing to the mass heated being extremely small, consisting chiefly, as it does, of an almost molecular cloud. How far the "arc" may be capable of longitudinal splitting after the manner of a wire or otherwise it is impossible to say; but this, again, lies within the province of inventors.

The object of this paper is not to afford any practical solution of the problem of dividing the electric light, but to show that such division is not, at least theoretically, impossible, and to endeavour to make clear the conditions which inventors must fulfil in order to arrive at such practical solution.

ON SPIRALITY OF THE ENERGY IN BAR MAGNETS.

BY R. C. SHETTLE, M.D.

1. The very extensive field of research as to the cause of magnetic and diamagnetic phenomena has been brought within the compass of a brief paper by a new method of investigation and the discovery of the law regulating the force upon which the phenomena depend.

2. The method consists in an examination of the lines of force in bar-magnets of low power, by means of test-magnets made from the points of the finest needles; such test-magnets being suspended with the greatest delicacy.

3. The great superiority these needles thus suspended possess as methods of research must be obvious—

1st. From the fact that the lines of magnetic force are always projected in lines of greater or lesser curvature, and,

2nd. From their extreme lightness and delicacy of suspension they are capable of being moved by magnetic force of very low power.

It has been ascertained—

1. That the equator of a bar-magnet is oblique and decentred.

2. That the impulses of energy or force pass from the equatorial direction towards the pole ends in oblique lines.

3. That similar impulses of energy or force pass from the pole ends towards the equator.

4. That the momenta or impulses of energy meet at a given point which is called for convenience of description the crucial line, that they then collide and are ejected in parallel lines from the side of the pole at such point.

5. That the energy which passes from the equator towards the crucial line, for convenience of description is considered as that primarily induced; or the *action* which is developed by external force, the direction and energy of which action must correspond with the direction and energy of such external force.

6. That the energy which passes from the pole end towards the crucial line is—also for convenience of description—considered as secondary; or as the *reaction*, which according to Newton's third law of motion is always equal and opposite to action.

7. That this reaction takes place within the pole end in proportion to the capacity the body operated upon offers for force.

8. That the power of exhibiting magnetic phenomena is due, and in proportion, to the energy with which these lines of force collide as they emerge from the bar.

9. That the momenta or impulses from either direction are oblique and characterised by leverage, which leverage results from the resistance to velocity which the two forces—action and reaction—mutually exert at the colliding line.

10. That this leverage increases from either direction towards the crucial line; and consequently, the needle points resting on the magnet, and which are indices of the direction and degree of force, gradually become less oblique, until at the crucial line they take a direction at right angles to the axis of the bar.

11. That the needles acquire a perfectly vertical direction

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when situated over a point where such impulses from all directions meet at a common centre.

12. That an inclined plane and a lever which are thus found to exist combined in all magnetic force is essentially characteristic of screw or helical motion.

13. That magnetic *attraction* is due absolutely to two helices of force of similar extension working into each other from opposite directions.

14. That magnetic *repulsion* is due to two helices of force of dissimilar extension working against each other from opposite directions, precisely in the same way as the momenta or impulses of energy from two opposite directions meet at the crucial line.

15. That the iron filings test, when two dissimilar poles are opposed, can be explained, and explained only, on the assumption that two similar helices of force are thus working into each other from opposite directions.

16. That the iron filings test, when two similar poles are opposed, is characteristic of two dissimilar helices of force from opposite directions mutually repelling each other, just as at the crucial line.

17. That this hypothesis with regard to the cause of the various positions of the needle at the crucial line has been determined by 210 observations.

18. That these observations consisted in placing one of the magnetic needle points on every portion of every surface of the pole end of one bar-magnet, and then subjecting it to the influence of every surface of a *similar* pole of another magnet; when it was found that upon the two poles touching, the needle took the same position along the line of junction of the bars, as along the crucial line of either bar.

19. That in taking such positions as the one bar was approached to the other, four descriptions of movement of the test magnets occurred—

1st. Directly upwards and backwards when placed on the median line.
2nd. A wheeling to the right upwards when placed on the right of the median line.
3rd. A wheeling to the left upwards when placed on the left of the median line; and
4th. A movement directly outwards when placed on the edge of the stationary bar within ⅛ of an inch of either angle.

20. That the direction of these movements may be changed by altering the relative positions of the two bars.

N.B. For the due conduct of any of these observations it is essential that the degree of energy in the two bars should be as nearly equal as possible, and, if any difference exist, that the moving bar should be the most powerful. The importance of this will be estimated when it is remembered that the needle resting on the end of one bar becomes for the time a point, from which accumulated energy emerges from the bar at rest.

ON THE MOTION OF THE SUSPENDED TEST MAGNETS.

21. That when the very fine magnetic needle points as described above are suspended over the various portions of the magnetic poles they become very sensitive indicators of any motion of force in the bar magnets.

22. That when a quarter-inch test magnet is moved over the first inch and a half of the south pole surface nearest the geometrical equator, a double polarity is experienced, the bar-magnet attracting the north pole just as usual, but when the test-magnet has been laid on the surface of the bar-magnet and is raised again, the south pole will leave the bar *last*.

23. That when delicate one-sixteenth or one-eighth test-magnets are held over the surface of a bar-magnet they are propelled obliquely towards the edges of the poles, the area over which such repulsion is manifested increasing from each side towards the centre, or axis of the poles, as the distance from the equator increases, until a point in the axis of the bar has been reached where the two lines meet, beyond which it is impossible to carry the needle to the pole end without repulsion to one or the other side; the direction of this movement being obliquely upwards and outwards with a convexity towards the equator.

24. That when the test-magnet is carried on one or the other side of this line towards the pole ends it requires to be forcibly dragged through the axis of force, after it has crossed which line it is whirled to the opposite side of the bar.

25. That after passing the crucial line similar movements take place, their direction is obliquely upwards and outwards as before, but with the convexity towards the pole end.

26. That oval centres of magnetic action are thus formed on each surface of each pole, the centre of which is at the point where the test-magnet takes a vertical position over the junction of the longitudinal and transverse axes of force.

27. That the above facts are sufficient to prove that the impulses of energy in magnetic force are of a spiral character; and, therefore, that Ampère's theory, which is based upon the existence of closed circuits of voltaic electricity is found to be incorrect by these experimental observations.

28. That the direction of the energy moving in magnets, and the fact that the principal portion of the force emerges from magnets at right angles to the axis of the bar, proves that the geometrical axis of the bar is at right angles to the principal axis of magnetic force, and, therefore, that the movement of the astatic needle is due to an attempt *to bring the current in the needle parallel to the current in the wire.*

29. That the facts above enumerated are strictly in accordance with the principles of conservation of energy. *Magnetic phenomena being manifested by bodies in proportion as their capacity for force causes reaction to be established at a point of the bar short of the pole end.*

DIAMAGNETISM.

30. That in addition to the facts named above, each of which tends to prove the spiral motion of magnetic force, diamagnetism will be found to accord entirely with the spiral movement of the force; and as diamagnetism does not agree with Ampère's law this is a point of considerable moment.

31. That diamagnetism *increases* as the power of a body to develop re-action *diminishes*. This is proved by the experiments of Sir Geo. Airy "in the directive power of magnets;" for he shows that the pole of the steel magnet is distant from the end about one-twelfth of a magnet's length; but the pole of the galvanic coil is absolutely at its end, or, a little beyond the end (*Phil. Trans.*, 1872).

Therefore, as the difference in the situation of the pole is determined by the matter in the core of the coil, it naturally follows that the greater the distance to which the crucial line is removed from the pole end towards the equator, the greater must be the capacity which the bar exhibits for force; and as the converse holds good with regard to diamagnetism, the absence of this line of demarcation between action and re-action, proves that bodies exhibiting such phenomena have very little influence in delaying the transmission of the force or of generating such re-action, and consequently that diamagnetism must increase as the power to develop re-action decreases.

32. That paramagnetic bodies take the *axial* line in proportion as their capacity for force enables them, under the influence of impressed force, to draw into and transmit through their structures with great rapidity the force that has emanated from all parts of the magnetic poles.

33. That diamagnetic bodies take an *equatorial* direction in proportion as their *low* capacity for force causes the largest surface of the body to be exposed to the greatest influence of the force, so as to permit structural saturation being effected with the slightest possible impediment.

34. That the tendency of paramagnetic bodies is consequently to attract the lines of force, as through a funnel, to a central axis, and is typical of magnetic attraction; whilst the disposition of diamagnetic bodies is to spread the lines of force as through an inverted funnel, and thus is typical of magnetic repulsion.

35. That the movements of the solenoid give proof that a highly diamagnetic body may be converted into a sensitive paramagnetic body, simply by giving a spiral direction to the force which traverses it. Whilst, as far as can be ascertained, every other phenomenon in magnetism, electro-magnetism, or magneto-electricity, can be explained upon the same basis.

LITERATURE.

The Telephone, the Microphone, and the Phonograph. By Count Th. du Moncel. C. Kegan Paul and Co.

Le Téléphone, le Microphone, et le Phonographe. Par Le Comte Th. du Moncel. Hachette et Cie.

[FIRST NOTICE.]

We have above inverted the order in which these works were published, the English work being a translation of the French. In several instances the translator has, with the consent of the author, inserted or left out a paragraph which appears in the original. As most of our readers will probably be more interested in the English than in the French edition, we shall confine our remarks almost entirely to the former. The work is popular in nature and deals with a very popular subject. It has long been a wonder to us that England has produced no counterpart of Count Th. du Moncel—a man to do for electricity in England what he has done for it in France. America, as usual, has recognised the value of the popularisation of science, and Prescott has published a popular work on similar subjects. The translation before us, in conjunction with Prescott's work,

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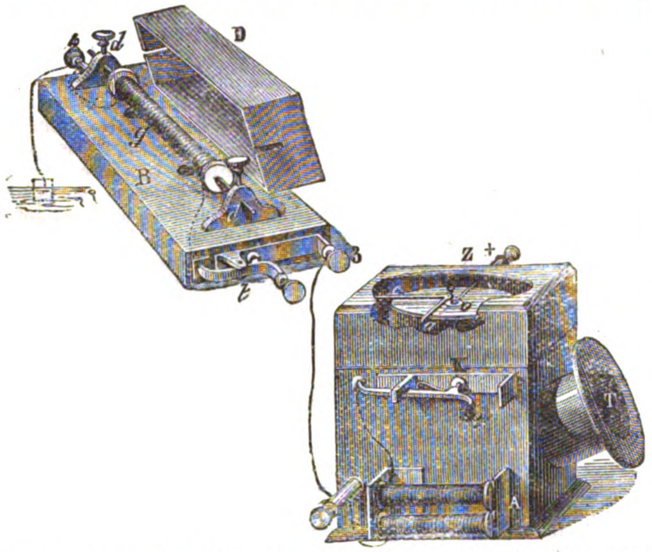
fills the void to a certain extent, but it seems to us that an Englishman writing specially for an English audience, with a complete knowledge of his subject, and keeping in view the idiosyncracies of his countrymen, would have succeeded better in giving exactly what is required. We are, however, thankful for what we have received. Count du Moncel commences his work by glancing at the history of the telephone; and we cannot but help being gratified at the way in which English papers have contributed to this history. In fact, scarcely half a dozen pages of the whole work can be read without meeting with copious references to English authorities. He gives at the commencement of his labours Mr. Preece's reference to Hooke's work in 1667, then refers to Wheatstone in 1819, to Page in 1837, and dwells upon the remarkable paper of Bourseul published in 1854, continuing with Gray in 1874 and 1876, and Bell in 1876. It is now well known that Gray and Bell troubled the American patent office on the same day. The musical telephone of M. Reiss is thus described:—"This telephone is, as far as the reproduction of sound is concerned, based upon Mr. Page's discoveries in 1837, and, as regards electric transmission, it is based on the vibrating membrane of which Mr. L. Scott made use in his phonautograph, in 1855. This instrument is composed, like telegraphic systems, of two distinct parts, a sender and a receiver, as represented in Fig.



The sender was virtually composed of a sounding box K, having on its upper surface a large circular opening, across which a membrane was stretched, and in its centre there was fitted a thin disc of platinum *o*, above which a metallic point *c* was fixed, and this, together with the disc, constituted the contact-breaker. On one face of the sounding-box K, there was a sort of speaking-tube, for the purpose of collecting the sound, and directing it to the interior of the box, in order that it might then react upon the membrane. Part of the box K is broken away in the plate, in order that the different parts of which it is made may be seen. The rods *a*, *c*, which support the platinum point *b*, are in metallic contact with a Morse key *t*, placed on the side of the box K, and with an electro-magnet A, which belongs to a telegraphic system, intended to exchange the signals required to start the action of the two instruments at their respective stations. The receiver consists of a sounding-box B, on which rest two supports *d*, *d*, bearing an iron rod of the thickness of a knitting-needle. An induction coil of insulated wire *g* is wound round this rod, and the whole is enclosed by the lid D, which concentrates the sound already increased by the sounding-box; for this purpose the box is provided with two openings below the coil. The circuit is completed through the primary of this coil by the two terminals three and four, and a Morse key *t* is placed at the side of box B, in order to exchange signals."

RECENT PATENTS.

3744. Telegraphing on Board Ship, *E. A. Caminada.—Dated 21st September*, 1878.—(*Complete.*) 6*d*.

This consists in the construction of an electrical rudder-motion indicator and electrical telegraph for use on board ships, and the construction of the transmitters or contact makers belonging to them, based on the following principals and conditions: First, that the same circuit cannot be used but to transmit one and the same signal to one indicator or to several indicators simultaneously, and to complete as many separate circuits as there are signals or orders to be given from one transmitter, one indicator, or to several indicators simultaneously; this is to be effected by one and the same contact maker, that is to say, that the one contact maker used to complete one electrical circuit must be adapted to create them all in one set of instruments. Secondly, the use of a separate circuit for every signal, for the purpose of constructing electrical motion indicators, or electrical telegraphs on board ships.

4007. Electric Clocks, *R. H. Brandon.—Dated 10th October*, 1878.—(*A communication.*) 6*d*.

There is adapted to the extremity of each branch of the escapement a tip in virgin silver or other good conductor, and on the escapement wheel a projecting pin in gold or other good conductor, which at its rotation comes in contact with each silver tip of the escapement. It is necessary to shorten the tooth of the escapement corresponding to the gold pin. It is also necessary to insulate the pivots of the axis of the escapement, for which purpose it is preferred to bush the centre of the same with a piece of ivory or other non-conductor, which in its turn is bushed with a metal tube.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices May 21.		Business Done Week Ending May 21. Highest.	Lowest.
Anglo-American	55½,	6	56⅜	55½
Do. "B"	85¼,	¾	86	85¾
Do. "A"	27,	½	28	27
Brazilian	6 15-16,	7 1-16	7⅛	6 15-16
Cuba	8,	½	8 7-16	8⅜
Do. Ten per Cent. Preference	15½,	16½	16⅛	16
Direct Spanish	1¾,	2¼	2	2
Do. Ten per Cent. Preference	10½,	11	10⅞	10½
Direct United States	10¾,	11	11	10⅞
Eastern	7 11-16,	13-16	7 13-16	7⅝
Do. Six per Cent. Debenture	104,	7	—	—
Do. Five per Cent. do.	101,	3	103	102½
Do. Six per Cent. Preference	11¾,	12	12	11⅞
Eastern Extension	7 11-16,	13-16	7⅞	7⅝
Do. Six per Cent. Debenture	107,	9	109⅜	109⅜
German Union ex div.	7½,	8	—	—
Globe Telegraph and Trust	4 15-16,	5 1-16	5	4 15-16
Do. Six per Cent. Preference	10 15-16,	11 1-16	11⅛	10⅞
Great Northern	8¼,	½	8½	8⅜
Indo-European	20,	1	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9½,	10½	—	—
Submarine	220,	30	—	—
West India and Panama ex div.	1⅜,	⅝	1 9-16	1 7-16
Do. Six per Cent. Preference...x d.	8¼,	½	8⅜	8¼
Western and Brazilian	3¼,	¾	3 11-16	3½
West. Union Seven per Ct. 1st Mt.	112,	116	—	—
Do. Six per Cent. Sterling	103,	5	104	102

TRAFFIC RECEIPTS FOR APRIL, 1879.

Companies.	April 1879.	April 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	45,540 estd.	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,940	60	—
Direct Spanish Telegraph Company	803	746	57	—
Direct United States Telegraph Company	15,790	—	—	—
Eastern Extension Telegraph Company	21,060	21,753	—	693
Eastern Telegraph Company	37,846	32,210	5,636	—
Great Northern Telegraph Company	16,299	—	—	—
Submarine Telegraph Company	10,195	9,543	652	—
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Western and Brazilian Telegraph Company..	—	—	—	—
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NOTES.

The West Coast of America Telegraph Company, Limited.—Traffic receipts for the month ending 31st March, 1879, £3,700.

Mansion House.—The Lord Mayor will receive the delegates of the International Telegraph Conference and the members of the International Literary Congress at dinner at the Mansion House on Thursday, June 12. Among the foreign guests expected are M. Victor Hugo, Señor Castelar, Señor Mendès-Léal, M. Jules Simon, M. Ivan Tourgueneff, M. Edmond About, Signor Macchi, Dr. Kalisch, besides a representative number of distinguished English literary men.

Electric Light in the New York Post Office.—Five of Maxim's electric lamps have been placed in the post-office of this city to light the great room on the ground floor. The lamps are thought to act very well, and as they are hung high the glare is not unpleasant to the eyes. Each lamp gives about 5,000 candle-power, and is connected with a dynamo machine of about four horse-power. The light is that of the voltaic arc, and French carbons are used. Each carbon or candle will last about five hours, and when burnt out another lamp is swung into position in place of it. The working cost of each lamp is estimated at about 3 cents per hour.

An Electric Blowpipe (M. Jamin).—The author remarks that the electric arc which plays between two carbon conductors is a true current. If submitted to the influence of a neighbouring current, of a solenoid, or of a magnet, it experiences an action regulated by the laws of Ampère, identical with that experienced by any metallic conductor put in its place, but as its mass is exceedingly trifling its speed is considerable. The author takes advantage of this fact to submit small quantities of matter to an intense heat. By causing the arc to be driven upon lime, magnesia or zirconia, the light is directed downwards and its intensity is increased at least threefold.—*Comptes Rendus.*

A New Departure in Electrical Education.—We learn that Dr. Muirhead and Professor Ayrton propose receiving at their electrical laboratory, adjoining the telegraph works of Messrs. Latimer Clark and Muirhead, pupils who desire to receive a complete education as telegraph engineers, and especially those who are anxious to be trained in conducting original research in electricity and magnetism. In addition to their receiving practical instruction in the manufacture and testing of electrical apparatus and in the mathematical theory of electricity as technically applied to telegraphy, we understand that it is proposed that all the students shall be placed in charge of original experimental investigations. We need hardly refer to the difficult task of duplexing the long submarine cables in the Atlantic, Mediterranean, Red Sea, and Indian Oceans, successfully accomplished by Dr. Muirhead with his "inductive resistances," or to the numerous experimental researches of Professors Ayrton and Perry carried out in the electrical laboratory at the Imperial College of Engineering in Japan as evidence of the thorough training students are likely to receive.

Wire Binders.—Numerous complaints by millers have been made again and again regarding the wire bands used by reaping machines in America and elsewhere. A committee of the American Millers' Association has been testing with some success an apparatus for separating the pieces of wire from the corn. The apparatus consists of two trains of horse-shoe magnets placed in a spout through which wheat mixed with wire passed. Every piece of wire from pieces $\frac{1}{8}$ in. to 1 in. length was removed. The device was not patented, and the resolution of the millers to which we have previously referred against wire binding has been substantially withdrawn. A patented invention for the same work is described as consisting of a revolving iron cylinder, through which the wheat is passed. During each revolution of the cylinder it is twice automatically connected with and disconnected from an electric battery. Inside this cylinder an endless apron is run lengthwise. Each time the "circuit" is broken the cylinder is for a moment demagnetised, and the particles of iron it has picked up drop upon the endless apron and are carried out. To remove the little pieces of wire from cattle feed is as important as to abstract them from milling corn, and some apparatus for this purpose will have to be devised before all objection to wire binding is removed.

Subdivision of the Electric Light.—Writing to our contemporary *l'Electricité*, Mr. Lontin makes the following important statement:—"In all the works treating of the electric light, the opinion seems to prevail that there is necessarily a great loss in subdividing this light. In opposition to this view, I bring forward the following table of results obtained before the jury of awards for the Exhibition of 1878, class 27. The electric generator was an Alliance machine, of which the discs were connected for quantity. All the photo-electric regulators tried with this machine gave a light of about 300 carcel burners. This result having been obtained, I commenced experiments with my regulators, which, as you are aware, divide the current supplied to them, and this without any risk of failure. With a single regulator, I obtained an intensity of 300 carcels. Placing two regulators in the same current, each gave a light of 118 burners, or a total of 236 burners. The discs of the Alliance generator were then connected for tension, when I obtained the following result, on one circuit.

Number of Lights.	Light for each Lamp. (carcel burners.)	Total Light. (carcel burners.)
3	87	261
4	79	316
5	61	305
6	69	414
7	52	364
8	36	288
9	29·8	268
10	24	240
11	20·6	228
12	19	228

The anomaly which will be observed in the case of the five lights was verified by repeated measurements made by most competent experimenters.

Nonsense.—The following is a fair specimen of how the non-scientific reader is filled with wonderment, and the expectation of what is in the eyes of the electrician mere dreaming. A contemporary thus writes:—"Will wonders ever cease? Certain it is that marvels in scientific discovery are following one another in rapid succession. The most recent and the most wonderful appears simply incredible. A New York cable company has secured the exclusive right to the use of an electrical discovery wherewith at least two hundred and as many as two thousand words a minute can be signalled through a submarine wire! It is said that what

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could at the maximum speed be sent through the conducting wire between London or Paris and New York would be equal to the number of words contained in one number of *The Times* or the *New York Herald*, and it is also asserted that, by this process, an entire number of either of the above-named journals could be despatched through the cable from New York to London or Paris, or from London to New York, and be reproduced at those points in *fac simile* on a stereotyped block or plate, complete and ready to be printed from, in thirty minutes, and at a trifling expense. Not only is it possible to do all this, we are assured, but, furthermore, secresy and despatch may be obtained in this wise :—The sender writes on a piece of prepared paper, places it in a box, a handle is turned, the message returns to the sender, and at the end of the wire a blank sheet is sent to the person addressed. When the paper is heated the message appears on the blank sheet. To a Dublin gentleman whose name is well known in the scientific world—Mr. Thomas A. Dillon—belongs the credit of the invention, certain improved electric batteries controlled by the American Cable Company serving as the basis of a new discovery. With the combined use of these two inventions it is believed that the Company will be enabled to reduce the tariff for cable messages between New York and the five different countries to be directly connected with its cables, to the extent of from three to five cents per word. We have the further statement that the Anglo-American Company offered to buy the invention for £400,000; and that, as that Company lacked the proper electric instruments for giving effect to the new process, it would have been lost to the public world." We are extremely sorry to say that Mr. Dillon is *not* well known to us, but this is our misfortune.

THE "GARY MOTOR."—In a letter to the secretary of the Franklin Institute, says the Journal of the Institute, Professor Henry Morton, of the Stevens Institute of Technology, remarks concerning this application of magnetism for the production of motion as follows:—"This so-called 'Gary Motor' comes before the public in a double character. First, as a perpetual motion machine, which is to do work without transformation of energy. In this light I think we may at once dismiss it as a fraud or blunder, to take its place with materialisation of spirits, and other matters, which are not subjects for the investigation of scientific students. Secondly, however, Mr. Gary appears as the supposed discoverer of some new facts in reference to the action of magnets, which though they certainly can no more enable us to create energy than to create matter, may add to our means of utilising natural forces and existing sources of energy. In this view his claim of discovering what he calls a neutral line around magnets is worth investigation. On looking into this matter, however, I find that he has only re-observed a set of phenomena which are so old as to have been described in the *Principia* of Sir Isaac Newton, Book II., Prop. xxiii., Scholium to Theorem, xviii., where I find as follows:—'The virtue of the magnet is contracted by the introduction of an iron plate, and is almost terminated by it; for bodies further off are not attracted by the magnet so much as by the iron plate.' All Mr. Gary's experiments, which will work, are readily explained by the well-known principles of magnetic induction, by reason of which a piece of soft iron near a magnet is inductively magnetised by the same and reacts upon it, and thus 'contracts the virtue of the magnet' and neutralises its action on exterior bodies. There is no evidence whatever of the existence of any neutral lines about a magnet, but the very experiments cited by Mr. Gary as proving it simply demonstrate that in certain relative positions the opposing actions of a permanent magnet and a piece of soft iron magnetised by induction from it neutralise each other's effects upon a third magnetic body, such as a piece of iron or a compass needle. Fully to work out all the relations between the mutual actions of three such bodies in any case is of course a problem of considerable complexity, but by no means a new one, and among many others a very able discussion will be found in the *Philosophical Transactions* for 1831, by Sir Wm. Snow Harris, page 501 *et seq.*, under the title 'On the power of masses of iron to control the attractive force of a magnet.' An early memoir by the same author appeared in the Edinburgh *Philosophical Transactions* for 1829."

EDISON'S ELECTRIC ILLUMINATOR AND DR. DRAPER'S EXPERIMENTS THIRTY YEARS AGO.—Now that the publication of Mr. Edison's patents for electric illumination has made the public acquainted with the details of his process, it is well to recall what had been done on this subject many years ago. Dr. John W. Draper (says the *Scientific American*) in a memoir published in the *American Journal of Arts and Sciences*, 1847, and also in the *London, Edinburgh, and Dublin Philosophical Magazine* of the same year, gave an exhaustive examination of this subject. He used a strip of platinum, brought to incandescence by the passage of a voltaic current through it, and showed that the light emitted increases in brilliancy far more rapidly than the increments of temperature. The strip of platinum, brought to a proper temperature by the passage of the electric current, was connected with an index lever, which measured its expansion. The results thus obtained prove that the increase in the intensity of the light of the ignited platinum became very rapid as the temperature rose. At 2,590° Fah. the brilliancy of the the light was more than thirty-six times as great as it was at 1,900°. This paper is reprinted as Memoir I. in his recently-published "Scientific Memoirs" (Harper and Bros.). The facts he had thus obtained he applied practically in the construction of a lamp. At page 45, in the volume referred to, he says:—"Among writers on optics it has been a desideratum to obtain an artificial light of standard brilliancy. The preceding experiments furnish an easy means of supplying that want, and give us what might be termed a 'unit lamp.' A surface of platinum of standard dimensions, raised to a standard temperature by a voltaic current, will always emit a constant light. A strip of that metal, one inch long and one-twentieth of an inch wide, connected with a lever by which its expansion might be measured, would yield at 2,000° Fah. a light suitable for most purposes. An ingenious artist would have very little difficulty, by taking advantage of the movements of the lever, in making a self-acting apparatus, in which the platinum should be maintained at a uniform temperature, notwithstanding any change taking place in the voltaic current." This memoir treats of the whole subject of the incandescence of platinum very exhaustively, measuring the heat emitted, the light emitted, and its spectrum analysis. Gas companies and others, interested in the rivalry between electric and gas illumination, will do well to examine it closely. Though printed in 1867 the experiments it relates were made two or three years previously. Subsequently Dr. Draper used iridio-platinum, and found that he could obtain a much brighter light because of its greater infusibility. At that time the method could not be recommended for public use, because it required a nitric acid battery. The dynamo-electric machine has of late years removed that difficulty.

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THE TELEGRAPH STATISTICS OF BELGIUM.

On page 124 of the First Volume of *The Electrician* will be found a review of the Director-General's Report on the Belgian Telegraph Service for 1877.

M. Vinchent's "statistics" for 1878 being now published, we proceed to make the following extracts:—

For several years the increase of telegraphic correspondence in Belgium has been almost arrested. In 1877, for the first time, the number of private messages fell below that of the preceding year, and although the results for 1878 exceed even those of 1876, there are as yet no signs of the revival of trade from which much is expected.

The *increases* in the various classes of correspondence in 1878, as compared with the previous year, were as follows:—

	No.	Per cent.	Receipts. Francs.	Per cent.
Internal messages	23,516	1·2	12,541	1¼
International messages	27,227	3·8	23,070	3
Transit messages	9,924	4	5,141	1¾
Totals ...	60,667	2	40,753	2

The average product per message remains almost the same, except in the case of transit messages, on which it has decreased 2¾ centimes per message.

The proportions of the various classes of messages were as follows:—

	Per cent.
Government telegrams	1⅜
Bourse telegrams	9¾
Commercial telegrams	40⅜
Social telegrams	46½
News telegrams	2

Out of 1,966,473 messages exchanged between Belgian offices there were:—

"Urgent" messages	55,326	or 2⅘ per cent.
Repeated messages	74	" 1/250 "
Acknowledgment of receipt	122	" 3/500 "
Taxed registrations	969	" 11/250 "

"Urgent" telegrams securing priority of transmission by means of a higher charge have been accepted in Belgium for twenty-three years without causing any objection or inconvenience whatever. The charge for urgency was at first fixed at three times the ordinary rate. It was afterwards thought prudent to charge a quadruple rate, but in 1869, after three years experience, it was found possible to transmit these messages at double the ordinary charge. The double rate is obligatory for telegrams handed in after nine in the evening for transmission during the night, 7,529 out of 55,326 "urgent" messages being thus charged. This class of telegrams during the day comprises but 2½ per cent. of the whole traffic, which small proportion is explained by the nearness of the towns to each other, the large number of railway lines, the rapidity of the postal communications, and the large number of deliveries. A postal card charged at five centimes arrives as promptly in Belgium as many telegrams in other countries. If a telegraph system with the same number of offices and conducting wires were applied to a territory five or six times as large, the messages would be exchanged with the same promptitude, which would be a considerable gain over the post; whereas in Belgium this gain is often insignificant. Hence the necessity for a low tariff, and for multiplying the wires, the instruments, and the staff, in order to avoid all delay, which would make the employment of the telegraph useless.

Out of 1,000 ordinary messages, the time between the deposit at the counter of the sending office and delivery at the address of the receiver was as follows:—

	Messages.
Less than half an hour	771
Thirty minutes to an hour	200
An hour to an hour and a half	27
An hour and a half to two hours	2

This result should be considered satisfactory, taking into account the necessity, in some cases, for several transmissions, the time required for placing the telegram in an envelope, &c., for the messenger to reach the address, the signature of the receipt, &c.

In the case of 100 "urgent" messages, the time elapsing between reception and delivery was as follows:—

	Messages.
Less than ten minutes	49
Ten to twenty minutes	38
Twenty to thirty minutes	10
More than thirty minutes	3

To explain how it is possible for half of the urgent messages to occupy less than ten minutes in transit between the sender and receiver it is necessary to observe that a large number of these telegrams are exchanged between the Brussels and Antwerp bourses at hours when the correspondents are within a few steps of the instruments.

This instance shows the practical utility of priority in virtue of a higher charge. If the correspondents who direct their operations by means of questions and replies exchanged in ten minutes had to wait their turn, they would often be unable to avail themselves of the telegraph. This deprivation would not profit any one, for, in the proportion in which they exist, "urgent" messages do not cause any appreciable delay to the ordinary correspondence. In abnormal circumstances, such as an unexpected rush of traffic or the interruption of all the wires but one, there are, it is true, many urgent telegrams upon the single wire; but, without the power to obtain precedence by means of a higher rate, the sender of a message very important for his business or his family would find himself unable to use the wire, because the only available route was blocked by messages of secondary importance, the object of which would be equally well attained after a delay of two or three hours. At the present tariffs, even at international rates, the charge for urgency is accessible to persons in all positions when promptitude is demanded by an important interest.

The trans-Atlantic telegraph enterprises do not admit precedence by virtue of a higher charge, but when certain of their cables are interrupted, they raise their tariff, and by this means seek to reduce the number of telegrams to as many as can be transmitted during the twenty-four hours by the remaining cables. One understands the necessity for this step, but if the effect of it was to leave the lines unoccupied during several hours of the day, and the companies accepted, at the ordinary tariff, messages to go when the line was clear, would it not be an advantage to the public and the enterprise itself? This would be the equivalent of "urgency."

An eminent member (the late Colonel Robinson) of the St. Petersburgh Telegraphic Conference, taking part in the discussion of this question, stated the case precisely, with as much good sense as humour. "The international tariff being fixed at the rate of 1f. per country or region, fix it," said he, "at the rate of 3f., with a reduction to 1f. to every sender who requests that his message may be sent after the correspondence at 3f."

Priority with a higher rate has rendered many services, and has injured no one in the countries in which it has been in operation for a long time, or in those international relations where it has been adopted for more than three years.

If every difference of figure or orthography between the original message and the text reaching its destination be counted as an error, it has been ascertained, by the examination which is regularly made in the Belgian service, that there are a little more than three errors per 1,000 words transmitted, or, on the average, upon 54 messages. Almost all these mistakes, it is true, not altering the sense of the correspondence, are of no consequence to the public. Repetition can be obtained for 25 centimes, and it is a striking proof of the accuracy of the service that it is only demanded once for every 40,000 messages.

It is very rare that a despatch is completely lost in course of transmission. Nevertheless, this does occasionally happen, and no telegraphic service can offer absolute guarantee against non-delivery from this cause. The only safeguard lies in the acknowledgment of receipt. Although in Belgium this costs half a franc—twice as much as repetition up to thirty words—it is demanded six times in 100,000 messages—no doubt as much as a check upon the correspondent as upon the telegraph service.

Urgent and repeated messages, in addition to those with acknowledgment of receipt, are registered, and in case of serious delay or non-delivery by the fault of the service, the charge is refunded. The advantages of registration may be obtained for an ordinary message by an additional payment of 25 centimes. Registration is obligatory for code messages. Out of 969 taxed registrations in 1878, there were twenty-one on account of code language and 948 to secure the advantages named.

In order to render registration more attractive, the date and hour of deposit were transmitted and indicated on the messages. This had no effect upon the receipts under this head, and it was, therefore, discontinued.

There were in 1878 twenty-one telegrams in code language and twenty-three in secret cipher. All apprehensions as to the dangers of this class of correspondence are dissipated by a single fact. In a country where secret language has been officially admitted for fourteen years, it is only used for one message in 45,000.

In Belgium official correspondence is charged under the form of State despatches. "Service" messages can only be sent free by the Administration of Posts and Telegraphs and by the Railways. There were last year 9,956 State despatches, which, together with 89,727 prepaid replies, are included in the 1,966,473 interior messages.

Telegraphic remittances, at a charge of 1f., acknowledgment

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of receipt included, in addition to the postal rate, numbered 14,846.

In the four principal cities (Brussels, Antwerp, Ghent, and Liege) a letter or post-card bearing, in addition to the postage stamp, a 25c. telegraph stamp, is delivered express by means of the service of messengers organised for the distribution of telegrams. This service is conducted in a certain number of fixed posts connected by tramways. The letters and cards are received at all postal and telegraph offices, and may be deposited in the letter boxes and in special boxes provided on the cars. This service dealt with 51,286 letters and 48,467 post-cards in 1878, the receipts to the credit of the Telegraph Department being 24,938f.

A table is given showing the differences in the receipts of the Belgian administration on messages from the various countries of the world. From this it appears that there have been increases in the case of France (17¼ per cent.), Switzerland, Italy, and Malta, Spain and Portugal, Russia (16¾ per cent.) and America (2 per cent.), and decreases in the case of Holland, Great Britain (3 per cent.), Germany, Austria, Servia, Roumania, Turkey, Greece (14½ per cent.), Asia Minor, Persia and India, and Africa (Egypt, Algeria) (30 per cent.).

Although the correspondence between Belgium and abroad had barely increased 4 per cent. in 1878 (this increase being exclusively due to the additional correspondence with France arising from the Paris Exhibition), the number of telegraphic advices of ten words increased 51 per cent. as compared with 1877, being nearly two and a half times as many as in 1876.

"Urgent" international telegrams are taxed at three times the ordinary rate. They are admissible between almost all the European countries except Austria and England. They numbered 18,413 last year, or 3·19 per cent. of the whole traffic. Assuming each telegraphic "advice" to have replaced a message of twenty words, this class of correspondence caused a loss of 8,740f. to the Belgian department, while "urgent" international messages produced a profit of 51,223f.

The first years of application of urgency in the case of international telegrams give a proportionately higher result than in the internal *régime*, where the surtax is smaller, and where the system has worked for twenty-three years.

This would seem to reply to objections which represent urgency as useless in international relations, where, it is said, all telegrams are urgent. Senders who require priority do not complain or make any observation upon the triple charge, nor has the ordinary correspondence been delayed by urgent messages, while the administrations do not, of course, complain of an increase of receipts by which no one suffers.

Why, then, asks M. Vinchent, is "urgency" "rejected in certain countries amongst which we number, with regret, people to whom progress is no stranger?"

In addition to the revenue from State despatches and private telegrams, the Belgian Administration benefits by some accessory receipts, the chief being from letters and post cards delivered by its staff in the four principal towns, and for lines and apparatus provided by the State for certain railways which pay an annual rental. These accessory receipts amount to 28,882f., which, added to the revenue from telegrams, brings the total receipts of the Belgian Telegraph Department to the sum of 2,208,632f.

All the charges for telegrams are paid in stamps, except where the sum exceeds 500f., in which case certain offices receive cash. The telegraph stamps in circulation represented on the 1st January last a value of 165,892f.

Service Messages.—Free telegrams are sent on the business of the telegraph itself, and for the branches of Administration such as railways, posts, and navy. In 1878 there were 1,557,493 service messages.

Means of Correspondence.—On the 31st December last there were 5,234 kilometres of *lines* carrying 22,778 kilometres of *wires*, serving 648 offices, and working 1,161 instruments. There are only 225 metres of subterranean wires. The Morse instrument is in general use in all the offices, with the addition in the principal towns of the Hughes printer. A few offices work the A B C instrument. There are 1,143 Morse, 48 Hughes', and 10 A B C instruments in use.

A list is given of the number of telegraph offices open in the different countries—Germany leading with 4,872, next Great Britain 4,126, and France 4,264. In proportion to size of territory Switzerland and Belgium come first, Great Britain being fifth, and Russia last.

The total number of persons employed in the Belgian Telegraph Service in December, 1878, was 3,685.

Irregularities.—During last year the Administration received 178 complaints, chiefly of omissions, delays, or errors in the transmission of the internal correspondence. It was proved that 176 of these had no foundation, or were due to circumstances for which the regulations accorded no satisfaction. There were thus but *two* reimbursements of charge on nearly two million telegrams.

In the case of foreign telegrams, after making the necessary reductions there remained but eight irregularities imputable to the Belgian offices.

Expenses.—The cost of the first establishment, and of the successive extensions of the lines and telegraphic instruments, of the offices, and the necessary stores, &c., amounted to 3,880,287f., while the total annual expenses reached 3,332,971f., which includes 591,021f. paid by the railway companies in respect of their lines, which are used in certain circumstances for the transmission of the messages of the public.

Elaborate calculations are made in order to arrive at the net cost of each message, or of each class of correspondence. It is shown that the cost of dealing with the 4,593,006 paid and service messages, after certain necessary deductions, amounted to 3,294,088f. Thus if all classes of the correspondence caused the same amount of labour, the average cost of each telegram would be about 75 centimes. But the researches of the department, which take account of certain economies of labour obtained principally by increasing direct communication between the offices of transmission and receipt, show that each private internal message represents 14 units of expense; each private international message represents 8 units of expense; each private transit message represents 4 units of expense; each service message represents 11 units of expense. The unit is then proved to be equal to 6·29 centimes. Continuing the calculation it is shown that the net cost of each private internal message is 88 centimes, which shows a loss on this *class* of correspondence of 650,000f. for the year, while the gain on international messages—the average net cost being 50 centimes—is 410,247f., and on transit messages—net cost 25 centimes—253,805f. This shows a profit, after deducting the loss on interior telegrams, of 14,124f., but when we take account of the cost of service messages we find a deficit of 520,318f. (£20,800).

Calculation of Net Cost according to Distance.—From the whole expenses of the Belgian telegraphs, including interest on capital, the two following elements have been taken, and their proportion of the general cost traced :—

1st. The expenses of wires in regard to distance.—At the rate of 156f. per annum per myriametre of wire, and dividing by the 79,000 messages, which are sent over one wire in a year under ordinary conditions, the net cost per thousand telegrams transmitted over a myriametre is 2f.

2nd. The expenses of delivery of messages, which are estimated at 117f. per thousand telegrams.—Completing this calculation it is found that the net cost of 1,000 internal messages is 866f. 24c., which differs very slightly from the conclusion arrived at by a different method (88 centimes per message).

It is remarked that working expenses are affected more by the number of offices than the length of wire.

Calculation of Net Cost according to the Number of Words in the Messages.—In order to measure the effect that a few words more or less would have upon the duration of the transmissions, and on the net cost, the experiment has been tried of transmitting 100 messages, containing an average of 18 words, and 100 averaging 14 words ; these lengths being chosen because they were the averages in Germany before and after the tariff of 1876. It was found that the economy arising from four words per message less was 5·2 per cent.

From further experiments in transmission with series of telegrams, containing from two to thirty words each, it resulted that each word more or less increased or diminished the period of transmission of 100 telegrams seven minutes on the Morse and four minutes on the Hughes instrument.

General Observations on Net Cost.—Bases of Tarification.—M. Vinchent says :—"We are convinced that the following rules may be applied without serious error to the large and small telegraphic systems of Central and Eastern Europe :—'An international telegram costs at each of its terminal offices a little more than half of the net cost of an internal message of this same office. A transit telegram causes to the system it traverses an expense which may be calculated at about half the cost of the international messages of this system. Taking for point of departure the time necessary for the transmission of telegrams of eighteen words (actual average), and the cost of these messages to telegraphic administrations, each word less per message will diminish the time employed 3½ per cent., and the expense 2¼ per cent.' "

These data, M. Vinchent thinks, may be usefully consulted for the eventual reform of tariffs, if combined with other elements of appreciation, such as the interests of the correspondents and the degree of importance they wish to obtain. If, for example, a large system, wishing to tax a message of twenty words at 1f. for the interior, and to take off a part of its charge of 2f.

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upon international and transit telegrams, desired to arrange its tariffs in exact proportion to the respective net cost of these correspondences, it would raise its interior rate to 2f., and reduce (on condition of reciprocity, of course), its international terminal tax to 1f., and its transit rate to 50 centimes. It is not difficult to see that the disadvantages of such a step would much exceed the advantages. The public hold essentially to cheapness for internal correspondence. They are less concerned with the price of international telegrams. By doubling the internal rate the number of messages would be reduced to nearly half. Reduce to half the international tariff and you would not nearly obtain the increased traffic necessary to produce the receipts at the higher rate. Experience proves this even in regard to neighbouring countries.

M. Vinchent concludes his able report as follows :—" In formulating the deductions drawn from our calculations we have been careful not to attribute to the results obtained a mathematically rigorous signification. The figures might be rectified more or less by other estimates drawn from other sources, but a partial rectification would not invalidate the verified relations between the different categories of correspondence according to their nature, length, or extent of section. It is from these relations, from these relative appreciations, that we have borrowed arguments confirmed by the real interest of the public and by the nature of things."

MR. EDISON'S MOTOGRAPH TELEPHONE AT THE SOCIETY OF ARTS.

Whatever distinction belongs to Mr. Edison for having achieved a new kind of telephone was ungrudgingly accorded to him by the members of the Society of Arts on Wednesday evening last week. Following up the discoveries of Professor Graham Bell—or rather the results arrived at by their means—Mr. Edison constructed the carbon transmitter, proving, as Elisha Gray had done before him, that speech could be transmitted without the aid of electro-magnetism. Its reproduction however was still dependent upon the telephone proper; and to dispense with its assistance altogether—substituting something entirely his own—seems to have long been Mr. Edison's ambition. He already possessed the materials in the motograph, the principle of which he discovered as long ago as 1872; and the successful application of which to telephonic purposes as a Receiver was the subject of exhibition on the evening in question. It had been shown at the Royal Institution some weeks previously; and a full description of the instrument has appeared in the columns of this and other papers. Curiosity had somewhat abated; but a large audience nevertheless assembled to witness its performances and to have its details explained in a popular way. Mr. Conrad W. Cooke had charge of the invention; and this duty, as well as the self-imposed task of recounting the whole history of telephonic research, he performed in a very conscientious and painstaking manner. The facts were stated in their historical sequence, and each progressive, or distinctive, invention was clearly described. A little more care might have been bestowed upon the initial discovery of Graham Bell, and upon the points of resemblance and difference between his instrument and those of his imitators. But there was no intentional unfairness; and we are only sorry that the audience did not include all those writers who have lately taken to retailing scientific intelligence for the daily newspapers.

From the original discovery—for it is entitled to be called a discovery—by Edison, in 1872, that a current passing between two surfaces in frictional contact, one of which was moistened by a solution, accelerated their speed by reducing the friction, the Lecturer passed on to its application to relays for telegraph lines. The motograph relay was stated to be of extreme sensibility, and it had been tried under very severe tests; but a little more precise information about the extent of its adoption for ordinary working in America would have been acceptable. This class of invention presents itself in two distinct aspects, one demanding the attention of physicists, the other inviting the approval of practical men. It is probable that the reputation of this and many similar discoveries of late years would be more enduring if the appeal to utility were not so clamorously urged. This observation applies to the present development of the motograph principle. It is a telephone the diaphragm of which is made to vibrate by the varying friction of a light rod attached to its centre, and pressing upon a specially prepared and moistened revolving wheel. Unquestionably this is the loudest speaking telephone yet produced. Its conception is suggestive and instructive; its construction most ingenious; but the practical tests which followed showed that these are the limits to which concession need go.

At all these exhibitions the order goes forth "Repeat what I say." Some people insinuate that if this mode of procedure were not followed, the audience wouldn't know what was coming; and on the present occasion it was remarked that the language was not understandable but for the interpretation going beforehand. Of course there was the inevitable Mary and her little Lamb. This playful legend, as the American papers always describe it, has figured in every megaphonic, phonographic, and telephonic display for at least two years past. One really begins to suspect that Mr. Edison's inventions are specially trained to recite it; or else that this is the only Nursery Rhyme known to the Americans. The latter is perhaps the more feasible notion; for the choice, if there were a choice, is a most unfortunate one. Mary's Lamb as we all know, had a *fleece* as white as snow; but inasmuch as the sibilant sounds are defective in the best regulated telephones, and are conspicuously so in this the latest, "fleece" is converted into something the mention of which does not prepossess an audience in favour of either Mary or the telephone. Neither are the months of the year, or the days of the week the most discreet selections for showing off the aptitudes of an instrument like this. July was the only word that it rendered quite kindly; nearly all the rest would have been guess-work—if you hadn't "known what was coming." As to the quality of the tone—the quantity being unexceptionable—the lecturer himself was conscious of its peculiarity, and pointed out, after a sepulchral selection from God save the Queen, that we had not yet arrived at the rendering of operatic music by telephone. Prof. Tyndall, who was in the chair, seemed to be of a different opinion; and hastened to assure the auditors that if the instrument failed in the higher notes it must have been the fault of the singer. Perhaps it was. Music however is but imperfectly represented by ejaculations of high notes and low; and all we can say is, that if this was the human voice discoursing sweet music, the sounds from behind a mask at the pantomime are angelic notes divine. Whistling, however—not involving articulation—was produced with remarkable effect, and more naturally than anything of the kind heard before. As much could not be said for the cornet playing. It was louder, but not nearly so musical—in other words not so truthful—as by Mr. Gower's recent magneto telephone. The dominant or fundamental note of the diaphragm was, too, more obtrusive even than in that of Mr. Gower's instrument; and the inequalities of vocalisation were consequently greater. For distinctness, therefore, as well as for the faithful reproduction of the original sounds, especially when those sounds are spoken words, the simple magneto telephone is still far ahead of its more pretentious rivals. This is simply a matter of fact. It detracts nothing from the merit of Edison's invention, or from the value of it where loudness is wanted. The magnifying-glass reveals a great many ugly blemishes; and the people who prefer magnified sound will resign themselves, we suppose, to its imperfections. How many persons are likely to want loud-speaking telephones is a commercial question which concerns Mr. Edison alone. The scientific interest evoked by the instrument is of more solid and lasting importance. The problem of the magneto-telephone has hardly yet been completely solved; and the motor telephone, if it do not of itself need much elucidation, has upset some established notions about the vibrations of diaphragms, and has discovered new electrical properties the swiftness and delicacy of whose operations are still to be explained. It may well excite the enthusiasm of physicists like Professor Tyndall, whose words of warm commendation seemed to claim for the invention an intrinsic practical value which we are sure the audience did not attach to it. More instructive were his advice and encouragement to experimenters generally. All these wonders had come of patient, intelligent, industrious experiments in fixed directions. The scientist might confirm a theory, and occasionally predict its future; but it was for the trained ingenuity of the mechanist and inventor to convert the dreams of science into practical realities.

During the evening a telegram from Mr. Edison was read stating that great improvements had been made ;" no mouthpiece, much better articulation, much louder: Mr. Edison *himself* (sic) devised a new switch. 500 instruments are being 'rushed.'" It might be thought unfair if we did not give publicity to these announcements, which were evidently thought to be of supreme importance—by the sender, if not by the audience for whose benefit they had been specially wired across the Atlantic.

Some well deserved compliments upon the paper that had been read, and the usual votes of thanks, concluded the proceedings.

THE ELECTRIC LIGHT, &c.—We have received Dr. Paget Higgs' new work on this subject, too late, however, for any lengthy notice this week, but we hope to give our readers an account of it in our next issue.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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THE INTERNATIONAL TELEGRAPH CONFERENCE.

The President of the Society of Telegraph Engineers, in his inaugural address, pointed out that this year was a red-letter year in the annals of English telegraphy, inasmuch as for the first time the International Telegraph Congress was to meet on our shores. The time for the meeting is close at hand, as on the 10th of June the delegates will commence their labours. It may justly be asked, What is this Congress and what is its *raison d'être?* So far as we know, the only information open to the general public is that which has been given in our columns, and in the inaugural address referred to above. In that address, Lieutenant-Colonel Champain pointed out how the necessity arose for such a Conference. Telegraphy is but a new thing after all, and but a few years ago a telegraph line was the exception, and not the rule. So useful, however, was the new invention that its extension was wonderfully rapid, and soon a network of lines connected every important place. These lines were not stopped by the limits of a country, but passed to and fro, regardless that one inch was in one country, and the next inch in another. Such extension, however, necessitated some agreement between the nationalities using the lines, for although one government could make what regulations it pleased for the lines within its own borders, it could hardly do so for lines partly within and partly without; two or more interests had to be consulted, hence the Congress. "The International Congress does not," says Colonel Champain, "legislate for the internal traffic of the several States; one country may choose to tax its local messages by the word, or even letter; a neighbouring country may, if it pleases, tax on the twenty-word system, and give the address free; but international messages, that is to say, messages crossing the frontiers, are all taxed and generally treated in strict accordance with Convention laws, just as in railways administrations; one State may select for its internal traffic a broad gauge, another a narrow, and a third the metre gauge; but directly an international system of railways comes into play the States interested must obviously agree among themselves on a uniform standard, and on uniform working rules. Nowadays, international conferences to legislate on railway, postal, metric, and other subjects are frequent, but telegraphy was the first to be so treated, and since the date of the earliest meeting in Paris, twenty-six years ago, periodical assemblies have been held with considerable regularity."

Telegraphic matters, like all other affairs, are not born perfect. Experience here, as elsewhere, shows that some of the existing arrangements must be modified, others condemned as tending to retard instead of facilitating business, whilst new ones have to be elaborated. Thus the Congress meets at intervals of about three years, and considers all that experience has criticised adversely since its last sitting. At the present moment there are several subjects of importance to be considered. What constitutes a telegram? is a question which as yet has not been thoroughly answered. What languages shall be used for international messages? is another question of very considerable interest. An ordinary clerk can hardly be supposed to understand every language, and yet if perfect freedom is allowed, why should not the merchant in India use one or other of the many dialects of that vast country, or the Chinaman indite a telegram in Chinese. So long as the total number of letters to be symbolised is limited, the greatest objection, perhaps, is that the use of too large a number of languages causes a considerable number of repetitions of messages, and that, consequently, a loss to the company ensues; but the freest use of language would practically put an end to telegraphic symbolisation. The number of combinations of dots and dashes is theoretically unlimited; but, in practice, the paying limit is soon reached, and, therefore, we begin to feel the importance of restricting international messages to two or three languages.

The question of tariffs, again, has to receive careful consideration. Originally "the unit charge was for a standard message of twenty words, with double rates at night; and each contracting state was divided into a number of zones, with a separate charge for each zone, according to its distance from the frontier." Scarcely a conference has been held but considerable modifications have been made in the regulations concerning tariffs, and the tendency seems to be to recognise the word tariff pure and simple as the normal international unit. We understand that this is a question that will be considered at the forthcoming meeting, and it certainly seems to us that the word tariff is at once the best and simplest.

The form of accounts between the various telegraph ad-

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ministrations, and the intervals and manner in which they shall be exchanged, is by no means so simple a problem as it may at first sight be considered. We have thus briefly and rapidly glanced at some of the work a Congress of this kind has to perform, and may add that it is due to the arrangements made at previous meetings that a person can go into any telegraphic office in the world, and send a telegram to any other part of the world at a fixed charge.

It cannot fail to have a beneficial effect upon the international relations between the various administrations that the heads of the telegraph departments should meet at intervals to discuss such questions as those we have mentioned in relation to telegraphy. The official narrowness so often generated by the steady pursuit of one routine system is expanded and greatly benefited by coming into contact with other systems. The petty exceptions that are sure to take place even under the best regulated systems are soonest remedied and adjusted by the knowledge gained at conferences of the person or persons with whom one has to deal. Hence the great value of the courtesies which have been shown from time to time in the European capitals—Paris, Vienna, Rome, and St. Petersburg—where the Conference has assembled in previous years. We are glad that there seems no lack among those interested in telegraphy of a desire to extend a cordial welcome to the delegates so soon to be in our midst. The Post Office and the submarine telegraph companies, as those most affected by the decisions of the Conference, have established a reception Committee to arrange for extending such courtesies as may be in their power to the foreign delegates attending the Conference. Lord John Manners, the Postmaster-General, has invited the delegates to dinner on June 11; whilst the Lord Mayor, entering heartily into the scheme, has opened the Mansion House, and offered its hospitalities to our guests on the 12th of June. Facilities have been given by the directors of the Crystal Palace for a visit to that well-known centre of attraction on Saturday, June 14. On the 18th, the Society of Telegraph Engineers gives a *soirée* in honour of the visitors at South Kensington. Mr. J. Pender, M.P., chairman of several of the telegraph companies, gives a reception on the evening of the 20th at his house in Arlington-street. Arrangements are also being made that the visitors may be enabled to have the opportunity of visiting Windsor Castle and Virginia Water, the West India Docks, Woolwich Arsenal, Portsmouth, the fine Works of the Telegraph Construction and Maintenance Company, &c. These visits will be made in the intervals between the sittings necessary for the meetings of the committees appointed by the Conference, and for compiling and printing a record of the previous proceedings, to be submitted for confirmation at the next sitting. We can only hope that the fickle English sky will prove propitious, so that our visitors may be able to enjoy to the full the entertainments that have been provided for them.

BRITISH AND AMERICAN INVENTION.

It is but natural, perhaps, that many of our countrymen should look to Menlo Park, New Jersey, U.S., for the various improvements whereby the electric light will undoubtedly be made to occupy an extended sphere of practical utility. The "terrific" energy of the American inventor, his entire freedom from any diffidence or self-mistrust, his apparently boundless resources of ingenuity, as well as of pecuniary means, and the way in which he lays himself out to monopolise in certain directions the attention of the civilised world, all contribute to blind the ordinary observer to the immense wealth of matured inventive power which exists, almost unnoticed, at home, and to conceal from him the fact that Mr. Edison is actually learning what others have long known, whilst he is eclipsing these less demonstrative individuals in their own domain. In listening to some of our countrymen —shrewd enough in ordinary matters—one might fancy that there was an absolute dearth of adaptive ability amongst our own electricians. It is of some importance that those who are inclined to interest themselves in the prospective developments of electrical applications, in a commercial direction and on a large scale, should be undeceived in this matter. We are convinced that the capitalist, whether British or American, could nowhere find more able, trustworthy, and safe advice, assistance and guidance, in regard to such applications, than amongst our own electricians. But the capitalist needs to learn that the latter are, comparatively, as a rule somewhat backward in putting themselves forward, that they require to be sought out, and even, in many cases, impressed with the commercial necessity of solving certain problems which are within their scope of knowledge or endeavour. For the English electrician frequently has no ambition whatever to become a patentee on his own account; in fact he often has a horror of patents, and is conservative of certain old-fashioned notions of professional limitations. He is more at home in the atmosphere of study and unbiassed appreciation of scientific fact than in the arena of commercial scramble and contention. And thus, we think, he is the man of all others with whom the pushing capitalist should seek to enter into alliance.

Although the British electrician is not *par excellence* a patentee, he is none the less an inventor. We know of several who have, quietly stowed away in their note-books, sundry clever and well-considered "notions" which, in the western hemisphere, would be made quite sensational, and would even lead to much "interviewing." Many of these, probably, will, "from pressure of study and other avocations," be kept back until, in the march of that invention which follows the necessities of the times, in lines laid down by a few thinkers and discoverers, they are, if not reinvented, at least *covered* by some "fishing" patent. We trust that this hint of an undesirable contingency may have the effect of bringing to light some inventions of real value which have been kept in abeyance.

In our issue of May 17, of the present year, we gave some account of the specification and claims relating to "the second invention of Mr. Edison in development of his discoveries in connection with the use of electricity for lighting purposes." The final specification of this invention was filed on May 7. On the 17th of the same month was filed the final specification of the invention of Mr. J. T. Sprague, for "Improvements in producing the Electric Light." It will be interesting to compare some passages in these respective specifications, from which it would appear that there is a great similarity in some of the leading ideas which have independently occurred to the two inventors in question. Mr. Edison's claim is for "a candle or light-giving body for electric lights, in which particles of metal or metallic oxide are moulded into a mass adapted to the passage of the electric current and rendered luminous by the same, substantially as set forth." And one of Mr. Sprague's claims is "the use in a closed circuit, for the purposes of electric lighting, of compound incandescent conductors as described," viz:—"a conducting substance capable of carrying the current, united with a substance capable of becoming incandescent and luminous." Mr. Edison says:—"Metals or oxides of metals are made use of,

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which produce, in a comparatively large candle, sufficient resistance to render the whole incandescent. Finely-divided metal, or particles of metal, having a high-melting point, are caused to adhere by earthy materials, such as magnesia, or zircon oxide, or magnetic oxide of iron, or other substances that are with difficulty fused. The oxides of metals may be obtained by chemical precipitation or otherwise, and the candle is moulded, in either a dry or moist condition, by pressure. The fine particles of metal may be platinum, iridium, ruthenium, or other metals that can only be melted at a high temperature; the earthy materials such as are infusible, such as oxides of magnesium or zirconium, lime, silica, boron, or other suitable material." (We have here taken the liberty of making the meaning of the specification a little clearer, from a chemical point of view, than it was in our original text.) And Mr. Sprague says:—"For the purpose of maintaining the conductivity and conveying the current, I employ any conducting substance, such as carbon or any suitable metals, either as fine wire or rods, or in a finely-divided state, using only so much as is necessary to convey the current, while presenting resistance sufficient for the development of the heat. For the luminous agent, I employ any of the substances known to possess the property of becoming incandescent, such as various oxides, sulphates, carbonates, &c. Of the earthy metals calcium, barium, magnesium, aluminum, and such like. These materials I mingle together either by forming them into a pasty consistence with water, or by powerful pressure in the nearly dry state, so as to form them into thin plates or rods." "These earthy materials I intermingle thoroughly with finely-divided carbon or platinum, or in some cases I may make the substance in layers coated with the conducting material, or I may add to the earthy material salts which may afterwards be reduced either by ordinary chemical agency or by heat, as may be suitable."

We have no intention of giving an opinion as to the probable value of the means above specified for obtaining the electric light; and still less do we desire to point to any conclusion in relation to the legal complications which might possibly arise in consequence of the strong points of similarity in the specifications referred to. What we consider of interest is the fresh example of parallelism in the direction of the endeavours made, in totally different quarters, to solve a problem which has passed through various phases and stages, and which, so far as can be seen, affords but limited opportunity for any initiative. We have reasons for thinking that, for some considerable time past, the English inventor has been at leisure maturing ideas which, though perhaps in another direction, have been vigorouly and promptly acted upon elsewhere; and the lesson to be insisted upon is that, in a case of this kind, an inventor cannot always afford to take his own time in specifying and claiming the devices by which he may have realised a certain measure of success. Whilst we observe that the American inventor apparently confines himself to a "candle," in the form of a prism or cylinder "divided vertically except at the upper end," and the English inventor apparently confines himself to the principle of incandescence in a closed circuit, we perceive also that priority in relation to certain devices legally belongs to the former, and that this result is probably due to his promptitude in putting forward his claim to the invention of means which, to us at least, are, like some other recent inventions, not very striking in point of novelty.

Terrestial Magnetism and the Mariners' Compass.— Sir William Thomson has contributed a Paper with this title to the June number of *Good Words.*

CORRESPONDENCE.

THE CONTACT THEORY OF VOLTAIC ACTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to the contact potential of copper and zinc, Mr. Sprague remarks (p. 308) that "doubtless it is just proportional to their natural tendency to unite as an alloy." I am aware that this is the opinion of many eminent electricians, but I have sought in vain for any direct proof that an electrical effect can be caused solely by the chemical combination of two *simple* substances.

It is true that voltaic cells have been devised, in which the electrolyte is replaced by mercury or other fluid metal, having an affinity for one of the immersed plates, but careful experiments with such combinations go to show, that the electrical excitement has a purely thermo-electric origin. The balance of evidence seems to be largely in favour of Faraday's theory that "in considering this oxidation or other direct action upon the METAL itself, as the cause and source of the electric current it is of the utmost importance to observe that the oxygen or other body must be in a peculiar condition—namely, in the state of *combination*; and not only so, but limited still further to such a state of combination and in such proportions as will constitute an electrolyte"—"Exp. Res.," vol. 1, p. 273. No doubt the amount of electrical energy developed in the voltaic cell is proportionate to the chemical affinity of the oxygen and zinc. The mere combination of these elements will produce the non-polar energy, heat; but I cannot help thinking that the *polars* or *two-sided* nature of electricity is intimately connected with the *dual* or *two-sided* nature of the electrolyte necessary for the development of energy in this form in the voltaic cell.

To indicate the manner in which I think the molecular disturbance must be "properly directed," as referred to by Mr. Sprague in his concluding sentence, is my object in troubling you with this letter.—Yours, &c., J. Brown.

Belfast, May 26, 1879.

POTENTIAL AND INFINITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As Dr. Lodge, in his letter on p. 9, evades instead of answering my question, it is scarcely worth my while to say any more on the matter. I can scarcely imagine any one but Dr. Lodge is likely to imagine I merely wished him to admit that the "arrangement is experimentally impracticable." I was more modest in my requirements. I only want to learn how it is conceivable. To be told that "nothing is easier" does not enable my imagination to overcome what appears an invincible difficulty. I put it as an absolute obstacle in the way of those who follow Dr. Lodge and his fellow thinkers. Until he answers it I shall hold that he finds it so.—Yours, &c., J. T. Sprague.

DUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have read in yours and other journals accounts of the lecture (which I had also the pleasure of hearing) recently delivered by Mr. Preece, on the subject of duplex telegraphy, before the Society of Arts.

As it appears to me that an incorrect impression is likely to arise from certain statements of the lecturer, I beg to forward you for publication a copy of a letter I have sent to Mr. Preece.—Yours, &c., J. Muirhead, Jun.

May 28, 1879.

Dear Sir: I was much surprised to hear you say in your lecture on Monday evening, before the Society of Arts, that although I "had duplexed some of the cables of the Eastern Telegraph Company in the Mediterranean and Red Sea on Mr. Stearns' principle, Mr. Stearns had only recently succeeded in duplexing one of the Anglo American Company's Atlantic cables."

The inferences naturally drawn from this statement are, first, that in duplexing the Mediterranean and Red Sea cables I had either infringed Mr. Stearns' patents or used them with his consent; secondly, that I had not duplexed any one of the Atlantic cables or any of the long cables east of the Red Sea.

Now, it is within your knowledge that I absolutely deny using any of Mr. Stearns' patents, and that for years past I have challenged that gentleman to take legal steps to decide and enforce his claim, but he has not thought fit to accept the challenge, or take any action in the matter.

It is, I think, also known to you, that besides duplexing

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several cables of the Eastern Telegraph Company, in the Mediterranean and in the Red Sea, I have successfully duplexed the following long submarine cables:—

Suez to Aden	1,500 miles	in 1876
Aden to Bombay	1,800 ,,	1877
The Direct United States Cable, being the longest cable in existence	2,400 ,,	1878
Madras to Penang	1,300 ,,	1878

&c., &c., &c.

Altogether my system had been applied, and was in use upon upwards of 10,000 miles of cable before Mr. Stearns had succeeded in his long protracted efforts to establish duplex on an Atlantic or other long line.

The method I adopt is distinctly described in my patents, and has frequently been fully explained in the scientific and other journals, whereas we are not yet informed of the means Mr. Stearns has recently employed to duplex one of the Atlantic cables, and it will be obvious to any disinterested electrician who compares my specifications with those of Mr. Stearns, that I use no part of his inventions, as specified in his patents, but an apparatus, the novelty of which is not, and cannot be disputed.

You stated also in your lecture that Mr. Stearns had succeeded in obtaining twenty-five words per minute on the Anglo-American cable (1,800 miles). If you will be good enough to refer to the *Telegraph Journal*, of May 15th, 1878, you will find it recorded that upon the Direct United States Cable (600 miles longer than the Anglo-American), I obtained a speed of twenty-five words per minute. Now, our sending twenty-five words per minute on a cable 2,400 miles long is practically the same thing as sending about forty words per minute on the shorter cable 1,800 miles long.

I do not ask you to accept my unsupported statement as to the essential difference between mine and Mr. Stearns' system. Sir William Thomson, Mr. Varley, Professor Jenkin, Mr. Latimer Clark, Professor Ayrton, and others, and the higher authorities in the telegraphic world have given their opinion that my method is quite distinct from what Mr. Stearns claims by his patents.

Having regard to these well-known men, I think I have some ground of complaint as well as on my own account as on that of my friends associated with me in the matter in that you should have omitted to mention in your lecture upon the subject of duplex telegraphy the important works we had accomplished long before Mr. Stearns was able to duplex the only long cable he has ever been successful with—viz., the Anglo-American, and that you should have, in face of the high authorities I have cited to the contrary, stated as a fact that I had used Mr. Stearns' inventions.

I trust that you will do me the justice to read this communication at your next lecture, in order that some of the misapprehensions created on the last occasion may be removed.

I also request the favour of this letter being published with your lecture in the proceedings of the society.—Yours, &c.,

J. MUIRHEAD, JUN.

May 16, 1879.

THE AUDIOMETER.*

BY BENJAMIN WARD RICHARDSON, M.D., LL.D., F.R.S.

Professor Hughes having done me the honour to show me first his newly-invented instrument for the measurement of hearing, and having supplied me with an instrument for the purpose of testing the application of it for physiological and practical purposes, I have been enabled to make a considerable number of experiments, on which I venture to submit the following preliminary report:—

The instrument, as it has been used, is before the Society. It consists of two Leclanché's cells for the battery, a new and simple microphonic key connected with the cells and with two fixed primary coils, and a secondary or induction coil the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, and the bar is graduated into 200 parts, by which the readings of sound are taken. The graduated scale is divided into 20 centims., and each of these parts is subdivided into 10, so that the hearing may be tested from the maximum of 200 units to 0°—zero. The fixed coil on the right hand contains 6 metres of wire; the fixed coil on the left hand contains 100 metres. By this means a long scale from the left hand coil is produced. The secondary coil contains 100 metres of wire.

In using the instrument, one Leclanché's cell has been found sufficient, as a general rule, but two have been used in instances where the hearing of the person under test has been very defective. The Leclanché cell was selected by Professor Hughes as affording a reliable current for the purposes he had in view, and for standard comparisons. In using the instrument, the induction coil is moved along the scale from or towards the larger primary, as may be required, and the degrees or units of sound are read from the figures on the scale, the sound being made by the movement of the microphonic key between the battery and the primary coils.

The person whose hearing is being tested should sit in an easy position, and should not see the act of the observer in moving the microphone key. For good observation, the room in which the experiment is made should be large, and all external causes of sound, such as the ticking of clocks, the vibrations of windows and doors, the moving of feet and the singing from gas jets, should be silenced. The sitter should close the ear that is not applied to the telephone while he is listening for minute sounds, and should give his full and calm attention to the proceeding. Any excitement is like to lead to error when refined measurements are required.

Capacity of the Instrument for Observation.—The instrument may be considered to afford the most satisfactory means for testing the hearing power of all persons who can define a sound. The range of sound is sufficient at the maximum—200°—for every-one who is not absolutely deaf; 0°, or zero, is a point of positive silence from the instrument, or rather from the sound which it produces through the telephone.

Phenomena from Observations made on different Persons.—Abrupt Loss of Sound.—One of the first facts learned with the audiometer is the suddenness with which the sound is lost to those who are listening. The sound is abruptly lost within a range of 2°; that is, within one-hundredth part of the entire scale. This is the case with those who are very deaf as well as with those who hear readily, a fact originally noticed by Mr. Hughes, and which I have corroborated by fifty special observations on different persons presenting powers of hearing which varied from 200° to 140° as the extreme limit or capacity, to complete hearing through the whole scale, down to zero. In these persons, when the observation was taken, under the strictest possible conditions for surrounding silence, the point between distinctness of sound and complete loss of it was not more than one-hundredth part of the scale.

Continuous Hearing in Line.—In testing the capacity of hearing, it is noticeable that the power to detect the diminishing sound is maintained best by continuing the reduction in trace or line while the attention is fixed. A sudden break may cause the sound to be lost to the listener long before his real incapacity to hear is reached. If, for instance, the sound be very faintly heard at 15°, and the induction coil be suddenly moved to 5°, the sound at 5° may be quite inaudible; but if the coil be slowly moved, unit by unit, from 15° to 5°, the sound at 5° may be distinctly heard. Mr. Maitland Tate, C.E., who noticed this point very markedly in his own case, when I was submitting him to test, compared this to what is observed by the sense of sight in making surveys. The eye will follow a line to an extreme point with comparative readiness, but if it break away from it, the object seems to have disappeared.

Influence of Respiration on Hearing.—The effect of filling the chest and holding the breath makes a difference in listeners. The capacity for hearing is for a few seconds increased by holding the breath. Mr. Tate, who could hear with his right ear only down to 8° under ordinary breathing, could hear down to 5° when he held his breath. Another gentleman, who could hear only down to 100° under ordinary breathing, could hear to 80° when the breath was held with the chest full. Holding the breath with the chest not full fails to produce the same result.

Influence of Habitual Movements of the Body.—As a rule, the hearing of persons who are right-handed is most refined in the right ear, and as most persons are right-handed, it is found that the right ear is the best ear. This rule is, however, attended with many exceptions, since, for various reasons, some persons who use the right hand exclusively, practise for some particular purpose the use of the left ear, upon which that ear becomes more acute. Thus five physicians, who were right-handed, but who had accustomed themselves to use the stethoscope with the left ear, could hear to zero on that side, but had lost from 4° to 5° on the right side. Four other persons who were similarly circumstanced were able at once to account for the fact by the habit they had acquired of listening to a public discourse or sermon from the left side. Another point of interest attaching to this observation is, that the practice of using one ear for special refinement of the sense seems for the time slightly to impair the other ear, although there is no physical evidence of such impairment.

Influence of some Automatic Adjustment and of Memory, on Hearing.—Connected with the last-named fact is another, namely, that by this instrument the deaf are found to fail in capacity of hearing not only by reason of physical defect, but

* Abstract of a Paper read before the Royal Society.

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also by failure of memory of sounds. Thus in a youth who had suffered serious defect of hearing for seven years owing to partial destruction of the tympanum, and who in the right ear could only detect sound at 107°, there was an inability to catch all the sound lying between 130° and 107°, until he could remember what he had to listen for. By practising him then to detect the lowest sound that he was physically capable of receiving, I got him to detect this one sound more readily than those which came higher up. By further practice all the intervening sounds became audible with equal facility. These facts, which have been confirmed by another observation on a different person, seem to me to indicate that deafness from imperfection of the tympanum or other parts of the organ of hearing may be increased, beyond the mere physical failure, either from some lost power of automatic adjustment in the auditory apparatus, or from failure of receptive power in the cerebrum itself, so that the memory rendered imperfect is slow to assist the listener until by exercise of function its readiness is restored.

Influence of Atmospheric Pressure.—By use of the audiometer, the influence of atmospheric pressure on hearing is detectable. In my own case when the barometer is at 30° I can hear on both sides close down to zero; but below 30° I fail by 2° on the left side to reach zero. In another person a similar failure extends to a loss of 4°.

Observations on Lower Animals.—I have tried to determine in some of the lower animals whether there is the same sense of hearing as in man. In most animals it is difficult to obtain sufficient quietude to enable the observer to gather from expression or movement of the animal the information sought for. In two dogs, one a terrier, the other a field spaniel, I succeeded in making some good observations, and in them the range of hearing power seemed to be distinctly lower than it is in the human subject who has perfect hearing. In both these animals, which were healthy, and in the prime of life, the first indication of the detection of sound commenced at 10° on the scale. The detection was evidenced by the sudden expression of listening, by a slight change of position, and a slight dilatation of the pupils. This detection was clearly made on the instant, as if the sharp line of hearing were the same in them as it is in the higher animal.

PRACTICAL MEMORANDA.

1. The audiometer will, I think, be an essential in all physical examinations of men who are undergoing examination as to their fitness for special services requiring perfect hearing, such as soldiers, sentries, railway officials, and the like.

2. The instrument will be of great use to the physician in determining the value of hearing in those who are deaf, and in determining the relative values of the two organs of hearing. In one instance, already, I have been able by its means to detect in a person who was supposed to be equally deaf on both sides, that on one side the hearing is perfect close up to zero, while on the other side nine-tenths of the hearing is lost.

3. In other forms of diagnosis I have found the instrument useful. In a young person suffering from acute anæmia the hearing was so defective that on the right side it failed to detect sound at 18°, and on the left side at 15°. In ten days, during which, under a new regimen, great improvement took place in strength and general condition, the power of hearing had so much improved that the right ear was good down to 12°, and the left to 3°; an improvement of 6° on the right, and of 12° on the left side.

In another person who was subject to repeated vertigo, the giddiness occurring three or four times a day, the hearing was so defective that although the external ear on each side was clear and the tympanum natural, no sound could be heard below 30°. Under complete rest and attention to diet, the vertiginous attacks were in a few days removed altogether, and with that removal there was gain of hearing, on both sides equally, up to 5° on the audiometric scale.

4. The instrument may be used to differentiate between deafness through the external ear and deafness from closure of the Eustachian tube—throat deafness. In my own case I fail to detect sound by the mouth at 170°, and this I find is a fair average in those who are healthy. It represents the comparative value of communication by sound through the Eustachian canal and the external ear.

5. The instrument promises to be very useful in detecting the effects in the body of those agents which quicken or excite the circulation, such as alcohol and other similar chemical substances. I have some observations on these points in reserve for a further report.

6. The instrument promises to be of great service in determining the value of artificial tympanums in instances of deafness due to imperfection or destruction of the natural tympanum. The cotton artificial tympanums introduced originally by the late Dr. Yearsley, and the membranous tympanums introduced by the late Mr. Toynbee, F.R.S., have proved of much service; and by means of the audiometer I have been able very accurately to test their respective merits and to compare both with tympanums made of other material. The inquiry has led me to test different metals for this purpose, and to find in fine gold the substance for making the most useful and effective artificial drum. The Messrs. Ash, of Broad-street, have made for me various forms of gold drums, the best of which, perhaps, is a little cylinder which, with other forms, is placed before the Society. With one of these cylinders I was able to give to a young gentleman who had lost hearing on the right side up to 110°, from destruction of the tympanum, an instant gain down to 60°, a gain of 50° on the audiometric scale.

In this preliminary report I have omitted many subjects of interest, but I hope I have related enough to show that the world of science in general, and the world of medicine in particular, is under a deep debt of gratitude to Professor Hughes for his simple and beautiful instrument, which I have christened the audimeter, or, less correctly but more euphoniously, the audiometer.

LITERATURE.

25,000 *English Words not exceeding Ten Letters, and* 75,000 *Words of Southern European Tongues.* David Whitelaw, 43, Fleet-street, London.

We note the publication of the above, a work similar in its object, and in some respects similar in its construction, to a little work issued some time ago by the same publisher. The present compilation consists of two parts, as per title. The first part contains 25,000 English words, arranged alphabetically both as to their initial and terminal letters; and the second contains 7,500 roots *(sic)* of verbs of six "southern" languages—French, Latin, Greek, Spanish, Italian, and Turkish—and a table of terminations providing ten different endings for each "root" (stem?), thus making up the number 75,000 words. This part has the initial and terminal letters of the stems arranged in alphabetical order, a plan which in some cases facilitates the correction of telegraphic errors. The parts together form a work which, if they do not exhibit any signs of deep erudition in the compiler, must certainly have cost a considerable amount of labour and exhibits some ingenuity. It is, therefore, a matter for great surprise that the compiler, before collecting his materials, did not first ascertain what words could be legally employed as code words. Of the 7,500 verb stems selected from the six languages above mentioned, not a few of the stems are provided with endings which together form words that violate the grammatical rules of the language from which the stem is taken. Thus the Latin stem "affric" is provided with endings which ignore the fact that "affricari" is irregular in its perfect tenses. The deponent verb "amplexor" is provided with such erroneous endings as "abo," "amus," "avit," and "ent." The same remark applies to "arbitror," which, moreover, being a neuter deponent, excludes also the ending "anda." In the same page we note that the verb "asequor" is treated in a precisely similar manner, though it appears to us that there is less excuse for it than in the cases of amplexor and arbitror, as sequor, the primative of asequor, is generally given in Latin grammars conjugated throughout as an example of the third conjugation of deponent verbs. Referring to the "Table of Terminations," we were certainly not aware that the Latin language contained any such verb ending as "one," and we were inclined at first to regard it as a printer's error, but as on examination we find the same ending given on every page, it would appear that this explanation is scarcely admissible. However, from whatever cause the error may have sprung, it is in one respect more serious even than either of the preceding, as it affects every verb stem marked L^2. With regard to the French words contained in Mr. Whitelaw's compilation, a very short examination will suffice to show that by affixing the endings contained in table to the various French verb stems contained in the work a large number of illegitimate French words would be produced. Thus, the verb "partager" is provided with the usual endings of verbs of the first conjugation without any provision for the retention of the letter "e" between the stem and a long vowel, as is the case throughout the conjugation of the verb. So that we have partagames instead of partageames, partagasse instead of partageasse, &c. There are numerous instances throughout the work of errors from the same cause, but we select this as "partager" is often conjugated *in extenso* in French Grammars as an example of this particular irregularity or euphonic change. We note, moreover, that no provision is made for the reduplication of the final

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consonant of the stems of such verbs as "dejeter," "chapeler," &c. When a language which largely indulges in orthographical euphonic modifications even in its regular verbs is treated without any respect to the changes that take place from this cause it cannot fail but that many illegitimate words will be produced; and we think it worthy of notice that a considerable number of these illegitimate words would, if spelt according to the rules of the French language, contain eleven letters. As we are not concerned with the revision of Mr. Whitelaw's publication we content ourselves in this first notice of the work with the above specimens of the errors contained in it. That the telegraph companies bound by the St. Petersburg convention will refuse to receive coded messages containing such words as those referred to we cannot doubt; for they can scarcely direct their clerks to accept as legitimate such words as renvayerai (for renverrai), for the use of which when at school they would probably have received a threshing.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The eleventh half-yearly general meeting of this Company was held on Thursday, May 22, at the Cannon-street Hotel, the Right Hon. Viscount Monck, the chairman, presiding.

The SECRETARY (Mr. Richard Collett) having read the notice calling the meeting, and the minutes of the last ordinary general meeting, which were confirmed by the present meeting, the report of the directors was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, said that the half year ended on the 31st of December, and that the sums appearing in the balance sheet to be due to the company from sundry debtors had since been paid. They were merely balances in transit. Some letters had been forwarded to the Company's offices, relating to these balances, and one gentleman suggested that they should be treated as bad debts, and written off. On this he had only to say that the Company had never made a bad debt [hear, hear]. If gentlemen would recollect that the accounts submitted referred to a period long past, and that in the meantime these accounts had been adjusted in the ordinary course, they would not find fault with the apparently large balances due to the Company. With regard to the operations of the half year, he had the pleasure to state that there was a net increase in the receipts of £655 over those of the corresponding half year of 1877 [hear, hear]. It would not be fair to compare with the half year immediately preceding, for the first half of a year was always better for the Company than the second. The next time he met them he would compare their transactions with those for the June half of 1878, and he had no doubt that the result would be equally as satisfactory as the account which he was now comparing. With regard to expenses, the expenditure in London showed a decrease of £65, an increase at the stations was apparent only—it was not really referable to working expenses, in which there had been a decrease of £136. The reduction in the expenses to which he had referred was very creditable to his honourable friend, their managing director, who he knew exerted himself to the very utmost to keep down the expenses. The whole of the ordinary expenses of working the Company amounted to only 17 and a fraction per cent. of their earnings, which would compare very favourably with the rate at which other companies were worked. As chairman of the Anglo-American Telegraph Company, he knew that the expenses of the company were a fraction below those of this Company, but the enormously larger traffic of the Anglo-American Company accounted for the difference in the percentage of expenditure. He would give them an illustration of what he meant. If they had a station which received only one message in a day they had to keep an operator and pay him for conducting it. It was perfectly clear that the expenses of that station on the receipts would be enormous, but the same man could do a hundred times the work at the same pay, and, of course, every additional message they carried reduced the proportional expenses. It was in this way a telegraph company carrying a very large traffic like the Anglo-American Company was able to reduce the proportional expense of doing its work; and this Company might hope that as they went on their traffic would grow larger, and that the proportional expenses would gradually diminish [hear, hear]. With regard to the difference of opinion between the Company and the Western and Brazilian Telegraph Company, to which allusion was made at the last general meeting, they had entered into a compromise, without the expense of litigation, which the Board considered satisfactory to this Company. The compromise, however, referred only to the past, and had been carefully drawn so as not to prejudice the appeal they had made to arbitration with the view of varying the terms of the contract. He then moved the adoption of the report and accounts.

Sir THOMAS FAIRBAIRN, a director, having seconded the resolution,

A short discussion followed, and in reply

The CHAIRMAN said that with regard to the arbitration to which he had referred as between the Company and the Western and Brazilian Telegraph Company it was no question of money. As to the low price which their shares commanded in the market, he could only assign one reason for it; he believed that a security paying 5 per cent. permanently commanded a very good price in the market, and that the reason their shares did not command that good price was that though they were paying 5 per cent. their property was known to be of a precarious character—that was to say, if by accident their line of cable broke down the traffic would for the time suffer. The policy of the directors from the beginning of the Company had been to take such a course as would by the accumulation of a good reserve fund, make the 5 per cent. permanent [hear, hear, and cheers]. He believed that that was the only way to make their shares appreciated in the market. He had been asked what limit they would put on this reserve fund. He would only observe that the cost of their cable, with the concessions, was £1,280,000; of course, without the concessions, which they would not have to buy now, they could relay it for less. He would only ask them, in view of the question what limit they proposed to put on the fund, to compare its amount, about £200,000, with this £1,280,000, and then he would ask any man in the room appreciating the benefits of a good reserve fund whether he thought the time had come yet to talk about putting a limit to the fund. The expenditure on capital account now stood at £1,286,817, so that the expenditure since the contract was made for the construction of the cable had been only £6,817. As to the dividends being irregularly paid, he read the dates, and showed (amid applause) that since the first December dividend was paid in 1874 there had been a variation in that dividend of only two days in the time of paying it. As to the second interim dividend, which was paid in March, there had been a variation of only one day. The other interim dividends had been paid with the same regularity. He urged them not to credit every rumour, and everything which might be said against the Company out of doors. The arbitration with the Western and Brazilian Telegraph Company, of which they had given notice, was simply for the purpose of varying the terms of the contract between them; and this contract provided for arbitration in case of disagreement. As to the shore end of the Lisbon cable, it was interrupted by a ship's anchor, and they intended, if any such accident should occur again, to relay the cable with stronger shore ends, and move it out of the water way; yet he thought they would agree that it was wise for them not to pick up the cable till it was injured [hear, hear]. However, they had made all provision, so that a suspension of operations would be limited to the smallest time possible. As to using pressure on the Western and Brazilian Telegraph Company relative to the extension of that company's system by the laying of the line between Para and Demerara, they had frequently urged that company to keep its lines in order, and to work them efficiently, so as to be profitable both to themselves and to this Company. He was bound to say that the Western and Brazilian Company had laboured under very great disadvantages. He did not think that the pressure hitherto exerted could be improved on. This Company would not suffer if any accident occurred to its cable owing to its arrangements with the Western and Brazilian Telegraph Company. There would be no objection to the publication weekly of their traffic returns.

The report was then unanimously adopted, and the proceedings terminated with a vote of thanks to the chairman and directors, on the motion of Mr. John Newton, seconded by Mr. Aubertin.

REUTER'S TELEGRAM COMPANY (LIMITED).

The fifteenth ordinary general meeting of the shareholders of this Company was held on Wednesday, May 28, at the Company's offices, 24, Old Jewry, Colonel James Holland in the chair.—The report stated that the net profits for the year ending the 31st of December last, after payment of current charges and deducting rebate on unexpired subscriptions and bad debts, amounted to £5,627 13s. 1d., including £205 5s. 10d. brought forward from the last account. The usual interim dividend of $2\frac{1}{2}$ per cent. was paid in October last, and the directors now declared a further dividend of 8s. per share, equal to 5 per cent., free of income tax, making a total distribution of $7\frac{1}{2}$ per cent. for the year, and leaving a balance of £113 9s. 9d. to be carried forward.—The Chairman, in moving the adoption of the report, said that, considering the great depression of trade which had prevailed during the past year, and the excited state of general politics in England, the shareholders would not be surprised to learn that the profits of the past year were not so large as heretofore. When trade languished commercial telegrams would fall off, and this had been particularly the case in regard to India, where trade had been bad from many causes, amongst which were the famine, and bad harvest had prevailed. Amongst other difficulties with which they had to contend, was the loss by exchange on remittances, which amounted to nearly £1,000. Then as regards general politics, they had hardly recovered from the excitement into which England was thrown by the Turco-Russian war when the war in Afghanistan commenced. It was their duty to provide the earliest news, and in this they had been successful, both in the cases of Afghanistan and Zululand. Such telegrams, however, were very costly, as would be gathered from the fact that each word from India costs 4s. 6d., as an instance of which he mentioned that one of the leading daily papers had had to pay £600 for a single telegram from India. He merely mentioned that fact to show how expensive was the work of providing early intelligence. He thought that they might congratulate themselves for having done their duty in supplying the earliest intelligence, as in many instances they had not only been before special correspondents, but before the Government also, and this had been especially the case in regard to the great events of the Zulu war. He mentioned this as an evidence of the ability of the executive officers. Referring to the accounts, he said that the Government of Egypt appeared amongst the sundry debtors for between £4,000 and £5,000; but there was every reason to look upon that as a good debt, as by a recent arrangement 50 per cent. was to be paid down, and the remainder was to be paid by bills running at interest. The business of the Company was sound and healthy, and there was every prospect of improved results next year.—The resolution was seconded and carried unanimously; and Colonel Holland, who retired from the direction in rotation, was unanimously re-elected, as were also the retiring auditors.

TELEGRAPHING TO NEW YORK THE RESULT OF THE DERBY RACE.

The following are particulars, in Greenwich time, of the time occupied by the Direct United States Cable Company (Limited) in transmitting, on Wednesday, the 28th inst., the Derby result to New York by "Direct Cable":—

	H.	M.	S.
Message handed in at Company's office, Throgmorton-street, London	3	37	30
Message reached Company's office, 16, Broad-street, New York	3	38	29
Message delivered to addressee	3	39	0

Time occupied in transmission, 59 seconds.

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TELEGRAPH SHARE LIST.

Companies.	Closing Prices May 28.		Business Done Week Ending May 28. Highest.	Lowest.
Anglo-American	55¾,	56¼	55⅞	55¼
Do. "B"	85¼,	¾	85¾	85¼
Do. "A"	27¾,	28¼	28⅛	27
Brazilian	7,	½	7⅛	7
Cuba	8,	½	8½	8 5-16
Do. Ten per Cent. Preference	15½,	16½	16½	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	10½,	11	—	—
Direct United States	10¾,	11	11	10⅞
Eastern	7 11-16,	13-16	7⅞	7⅝
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	101,	103	102½	101¾
Do. Six per Cent. Preference	11¾,	12	12	11⅞
Eastern Extension	7 11-16,	13-16	7 15-16	7 11-16
Do. Six per Cent. Debenture	107,	110	109¾	109½
German Union	7½,	8	—	—
Globe Telegraph and Trust	4¾,	5	5	4 15-16
Do. Six per Cent. Preference	10¾,	11	11	10⅞
Great Northern	8⅝,	⅞	8 11-16	8⅝
Indo-European	20,	21	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9½,	10½	—	—
Submarine	220,	230	227	—
West India and Panama	1⅜,	⅝	1 9-16	1½
Do. Six per Cent. Preference	8,	½	8½	8½
Western and Brazilian	3⅝,	⅞	3 13-16	3¾
West. Union Seven per Ct. 1st Mt.	112,	116	—	—
Do. Six per Cent. Sterling	103,	105	—	—

TRAFFIC RECEIPTS FOR APRIL, 1879.

Companies.	April 1879.	April 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	45,540 estd.	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,940	60	—
Direct Spanish Telegraph Company	803	746	57	—
Direct United States Telegraph Company	15,790	—	—	—
Eastern Extension Telegraph Company	21,060	21,753	—	693
Eastern Telegraph Company	37,846	32,210	5,636	—
Great Northern Telegraph Company	16,299	—	—	—
Submarine Telegraph Company	10,195	9,543	652	—
West Coast of America Telegraph Company.	4,225	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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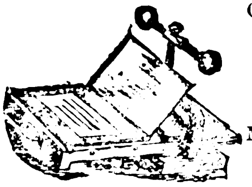

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NOTES.

The Electric Light at the Palais des Champs-Elysees.—The Jablochkoff Company has contracted with the French Treasury to illuminate this building with 250 bougies.

The Electric Light at Teheran.—It is stated that the introduction of the electric light has preceded that of gas in Persia, and that several Jablochkoff candles are consumed every night by the Shah in his palace at Teheran.

To Natal.—Major Webber, R.E., the chief of the military section of the Postal Telegraphs, and who has had charge of the South-Western and South-Eastern divisions of the country, has been appointed to attend Sir Garnet Wolseley to the Cape, who has no doubt an appreciative knowledge of his capacity. Although Major Webber has been qualifying himself in telegraph engineering, civil and military, he has continued his general military duties, and will, from his additional knowledge of telegraphy, be the better man. For his energy and industry he is well known, and although it is a matter of pleasure to his friends that he has received this appointment, it is also a matter of regret to them to lose so genial a colleague.

Hydro-Electricity and Hydro-Magnetism.—M. C. A. Bjerknes reports to the French Academy the results of experiments for verifying his theories. The experiments were performed in the physical cabinet of the University of Christiana with the aid of M. Svensden, and resulted in the complete verification of his theories. They embraced, first, the action between two pulsating bodies; second, between a pulsating and an oscillating body; third, between two oscillating spheres. In every instance, even when it was necessary to place the vibrating bodies where it was suspected that the disturbing action of secondary forces would become very strong, the results conformed to those of the analytical researches, whenever the vibrations were regular and had a nearly uniform intensity. The attractions, the repulsions, the normal displacements from the central line, and even the deviations around the centres of the oscillations were such as his formulas had announced.—*Comptes Rendus.*

Kerite.—This is the name given to artificial caoutchouc invented by Mr. A. G. Day. Its inventor claims it to possess eminent merits as a substitute for gutta percha for telegraphic cables. He states that the kerite core is not injuriously affected by extremes of heat and cold experienced in any climate nor by length of exposure to the atmosphere. He affirms that it will endure long-continued heat below 200° Fahr., and for short intervals as high as 250° to 300° Fahr.; that it may be safely immersed in boiling water; that salt and fresh water improve its insulation; that it is not injured by the roots of plants which soon destroy gutta percha; that acids act very slowly and only superficially upon it, while hot, concentrated alkalies do not affect it; and that mineral oils and illuminating gas, so far as is known, do not deteriorate its insulating qualities. It is further claimed, on the strength of samples of this core laid in the Caribbean Sea and on the Isthmus of Panama, that neither the teredo, so destructive to gutta percha in the former, nor the white ant of the latter, has harmed it.

Application of Brush Lightning Conductors in France.—The prison at Nîmes, containing 1,800 prisoners, is situated upon a rock 30 mètres high. A lightning conductor had not been erected upon this establishment from fear of wilful damage or facilitating escape. M. Fabre, of Alais, has been able to apply the brush lightning conductor of M. Melsens, like the one upon the Hotel de Ville de Brussels. The lofty points of ordinary lightning conductors are replaced by seven points, each seven mètres long and curved upwards. These brushes are placed at certain distances upon the roof, and connected by a number of intervening conductors. The building is thus enclosed in a kind of cage, which may be struck by lightning without injury to persons inside. As there are no pieces of water in the neighbourhood, the conductors had to be brought into communication by means of an extended circuit with the town water reservoirs and gas and water pipes. The conducting surface is sufficient to avoid any considerable tension upon the conductors. M. Alluard remarked that this system of lightning conductors has existed for 20 years at the Puy-de-Dôme.

Rock Drilling by Electricity.—M. Gaston Planté, in his "Recherches sur l'Electricité," mentions a new application of electricity which had not been hitherto published by him, and which is of considerable interest. After describing the process of engraving on glass by electricity that he made known in 1877, and the account of which has been so widely copied by scientific papers, M. Planté goes on to say: "We have seen that one of the electrodes conducting an electrical current of a certain tension, being brought in contact with glass, in the presence of a saline solution, it acts like a graver or diamond by tracing grooves in the surface of the glass, and even digs into it quite deeply. In spite of its great hardness, rock crystal can also be attacked by the same method; and, if not engraved regularly, it at least cracks into small fragments, and is finally disintegrated." In view of this, M. Planté suggests that the electric current, under conditions analogous to those above described, might be substituted for diamonds in the operation of drilling rocks. He states that electrodes of platinum would not be necessary, for here it is not the metal of the electrode that is affected, but the silicious matter in contact with a saline solution. Metallic points or projections, suitably located at the extremity of the drill, isolated on a part of its length and actuated by a rotary movement, would lead the electric current to the surface of the rock to be pulverised, and would thus replace those numerous and expensive diamonds which are set in the head of the drills employed in the present system of rock boring.

International Exhibition of Industrial Science at Paris.—An International Exhibition of the Sciences applied to Industry will be held in the Palais de l'Industrie, Paris, from July 24 till November 25, 1879. The President of the Superior Committee is M. Cocherie, Under Secretary of State at the Ministry of Finance; the Secretary-General, M. De la Bruyère, Administrateur de la Caisse d'Epargne de Paris; and the Director, M. P. Nicole, Administrateur-Général de l'Union Syndicate de Paris, who organised the Havre Exhibition in 1867 and the Exposition Maritime et Fluviale in 1875. The programme of the Exhibition comprises nine groups, with sixty-nine classes. In Group II. (Applied Physics) Class 5 includes all the more recent applications of electricity and the electric light; Class 6, the electric telegraph,

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with the various transmitting and receiving instruments, and the working of the telephone on telegraphic wires; Class 7, processes and specimens of electro-metallurgy; Class 8, optical instruments for both science and industry; Class 9, photography, including its new applications, and other means of utilising light; Class 10 (the production of heat and cold) embraces the utilisation of solar and terrestrial heat, machines for making artificial ice and for the liquefaction of gases, as well as instruments for measuring degrees of heat and cold; Class 11 (warming, lighting, and ventilation) includes fireplaces, stoves, apparatus for the use of mineral oil for domestic and industrial purposes, artificial gas and electrical illumination; Class 12 relates to hydrostatics, hydraulics, and pneumatics; and Class 13 to the production and utilisation of sound, acoustic telegraph, the telephone, aerophone, and phonograph.

THE MAGNETIC EFFECT OF ELECTRIC CONVECTION.—Prof. H. A. Rowland writes to the Editors of the *Philosophical Magazine*, that some three years since, while in Berlin, he made "some experiments on the magnetic effect of electric convection, which have since been published in the *American Journal of Science* for January, 1878. But previous to that, in 1876, Prof. Helmholtz had presented to the Berlin Academy an abstract of my paper, which has been widely translated into many languages. But, although Helmholtz distinctly says, "Ich bemerke dabei, dass derselbe den Plan für seine (Rowland's) Versuche schon gefasst und vollständig überlegt hatte, als er in Berlin ankam, ohne vorausgehende Einwirkung von meiner Seite," yet nevertheless I now find that the experiment is being constantly referred to as Helmholtz's experiment—and that, if I get any credit for it whatever, it is merely in the way of carrying out Helmholtz's ideas, instead of *all* the credit for ideas, design of apparatus, the carrying out of the experiment, the calculation of results, and *everything* which gives the experiment its value. Unfortunately for me, Helmholtz had already experimented on the subject with *negative* results; and I found, in travelling through Germany, that others had done the same. The idea occurred in nearly the same form to me eleven years ago; but as I recognised that the experiment would be an extremely delicate one, I did not attempt it until I could have every facility, which Helmholtz kindly gave me. Helmholtz kindly suggested a more simple form of commutator than I was about to use, and also that I should extend my experiments so as to include an uncoated glass disc as well as my gilded vulcanite ones; but *all else I claim as my own, the method of experiment in all its details, the laboratory work, the method of calculation—indeed everything connected with the experiment in any way, as completely as if it had been carried out in my own laboratory* 4,000 *miles from the Berlin laboratory.*"

ON ELECTRIC BOUNDARY LAYERS. — BY PROFESSOR HELMHOLTZ.—In all cases in which two contiguous bodies have different values of the electric-potential function, there must be along the common boundary between them a double layer of positive and negative electricity, the moment of which (taking this expression in the same sense as in the phrase "magnetic moment"), multiplied by 4π, calculated for unit surface, is equal to the difference of potential-function on the one side, and, on the other, of the double layer. Now, as the value of the moment is equal to the electric density of the positive E multiplied by the mean value of the distance between the two layers, this distance cannot become vanishingly small without the density with a given difference of potential becoming infinitely great. But the work done, in the formation of such a double layer, against the electrostatic forces is $= \mathrm{P\,E}$, if E denotes the amount of positive electricity on the unit of surface, and P the difference of potential on the two sides of the double layer. Since, with the distance h between the two layers, $4\pi \mathrm{E}\, h = \mathrm{P}$, the value of the work is $\frac{1}{2}\,\mathrm{P\,E} = \frac{1}{8\pi h}\,\mathrm{P}^2$, and would, therefore, become infinite for vanishing h. From this Sir William Thomson has already calculated a limit for the distance between the double layer at the galvanic tension between copper and zinc, according to which calculation it must be more than $\frac{1}{3} \times 10^{-7}$ millim. With this agree F. Kohlrausch's experiments on the capacity of galvanically polarised platinum surfaces for very weak charges, from which the distance comes out equal to the 2475000th part of a millimetre, if the potential-difference be assumed to be equally divided between the two plates. The author showed that the laws of the flow of water through capillary tubes and porous diaphragms, occasioned by electric currents, as ascertained by G. Wiedemann and Quincke, and the laws of the electric tension excited by the flowing of water between the beginning and the end of the course of the stream, discovered by the latter observer, can all be deduced from the hypothesis that a difference of electrical potential exists between the sides of the vessel and the liquid (which M. Quincke also assumed, and supported by many experiments), and that it is the part of the double layer falling in the water that both yields to the electric attractive forces on the tube being traversed by an electric current, and is also taken along by the introduced motion of the water. The boundary layer of the liquid must be assumed to be at rest against the sides of the tube, as in Poisseuille's theory of the flow of liquids in capillary tubes. In a series of cases the data supplied suffice for the calculation of the electric moment of the part of the double layer that falls in the liquid (in which calculation the opposite electricities must be assumed to be combined in the bounding surface). The values then obtained do not exceed those with which we are acquainted from the galvanic tensions between metals. Thus M. Wiedemann's experiments on the electric conveyance of sulphate of copper solution through clay diaphragms give the moment of the electrical layer in the liquid as equal to 2·4 Daniell's. M. Quincke's experiments on the height to which water, conveyed by electricity, ascends in glass tubes give 3·9 Daniell's; and his experiments on the electric tensions which arise when very dilute salt-solutions are driven through clay diaphragms give 1·9-2·7 Daniell's. As the electromotive force between potassium and platinum amounts to about 3·4 Daniell's, all the above-mentioned numbers lie within or but little beyond the limits of the observed differences of potential between metals. The assumption that the extreme boundary layer of the liquid adheres immovable to the sides of the vessel was founded upon the determinations made by M. Quincke of the heights of ascent of electrically carried liquid in cylindrical glass tubes, according to which they are inversely proportional to the square of the radius. This results from the theory only on the assumption that no sliding of the boundary layer occurs. The calculation was accomplished even for those cases in which a cylindrical thread is placed in a cylindrical tube; and it showed tolerable accordance with the observations, so far as could be expected with experiments so subtle and so disturbed by manifold influences.—*Monatsbericht der kön. Preuss. Akademie zu Berlin*, Feb. 1879, pp. 98—200.

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LECTURES ON SUBMARINE TELEGRAPHY.*

BY A. JAMIESON, C.E.

In my first lecture I traced the history of electrical science from its earliest dawn until the present day, pointing out what it had done for telegraphy in general, but leaving for a future and special notice its immediate connection with the "Rise and Progress of Submarine Telegraphy."

The successful laying of a cable between Dover and Calais in September, 1850, is, no doubt, the real starting point of submarine telegraphy, although many attempts had been made prior to that date to connect places by means of conducting wires covered with insulating material.

We find it stated by Mr. Varley at a meeting of the Society of Telegraph Engineers on the 9th February, 1876, that Professor Soemmering exhibited before the Emperor of Russia in the year 1807 or 1808 a little subterranean line of more than a mile in length, by which he was able to explode at one end a charge of powder by the application of electricity at the other end. We find the same Professor amusing the allied English and Prussian officers assembled at Paris in 1815 by firing charges of gunpowder through a line which he had laid across the Seine.

So confident was this gentleman of success that in 1818 a submarine cable was ordered to connect Cronstadt with St. Petersburg, although mention is not made of its success. These suggestions and experiments seem to have been forgotten until 1837, when we find Professor Wheatstone proposing a plan for connecting France and England by means of a submarine cable, and in 1840 he gave evidence before the House of Commons as to the practicability of his scheme. The drawings of the machinery whereby he was to make and lay the cable are still in existence, and copies have been printed in the *Journal of the Society of Telegraph Engineers*, Vol. V., No. 13. Viewed by our present advanced knowledge, the plans and suggestions of Sir Charles Wheatstone, no doubt, appear crude and insufficient, but remembering that he had no former experience or analogous operation to guide him, they must be regarded as a masterpiece of forethought and ingenuity.

In 1839 Dr. O'Shaugnessy, now Sir William Brooke, gives an account of his experiments and plans for crossing rivers and carrying out submarine telegraghs, which were made early in that year, and printed in the proceedings of the Asiatic Society for September, 1839.

In 1843 Professor Morse, in writing to the Secretary of the United States, expresses his belief in the possibility of establishing electrical communication across the Atlantic Ocean.

These suggestions, although clever and farsighted, could not be practically carried out for the want of a good insulating material, by which to prevent the electrical current from being lost in its passage along the conductor. However, in the winter 1844-5, Dr. Montgomery sent the first sample of gutta percha to the Society of Arts. It is a curious fact that Professor Faraday should have called public attention to the electrical qualities of gutta percha as quite a new and scientific discovery in February, 1848, although it appears that Dr. Werner Siemens had previously published and suggested to the Prussian Government its use as an insulating material for subterranean wires, and claims having invented the first machine in 1847 for covering wire with Siemens gutta percha. Still more curious is it to find that Professor Wheatstone contemplated employing gutta percha in the construction of his proposed cables in October, 1845, although it does not appear very clear in what way he intended to apply it.

The great plasticity and insulating property of gutta percha has borne out in a remarkable degree the suggestions of Wheatstone, the early applications of Siemens, and the scientific investigations of Faraday, as the best and most durable insulator for submarine cables.

We have an interesting account given by Mr. Varley, wherein he, Mr. West and Mr. Reece, in 1847, paid out into the sea a short length of india-covered wire, through which they telegraphed signals, and tested its insulation. This, he believes, to be the first time telegraph signals were actually sent under sea water.

In 1849, Mr. Walker, late president of the Society of Telegraph Engineers, sent a message to shore through two miles of insulated wire from a battery on board a steamer off Folkestone.

In 1850, Mr. Jacob Brett and his *confrères* were the people who first of all had the boldness to make and lay a cable successfully. They obtained a concession from the French Government, for effecting the object of connecting England with France, by means of a submarine cable, which was regarded at the time as a gigantic swindle. The cable consisted of a solid copper wire covered with gutta percha, of which this is a specimen. This cable was manufactured under the superintendence of Mr. Samuel Statham, at the gutta percha works. It was landed in France at Cape Grisnez, and laid to England by Mr. Read, but unfortunately failed a few hours after completion. It is humorously related that a diligent fisherman, plying his vocation, caught the cable in his trawl, cut off a piece, and bore it in triumph to Boulogne, where he exhibited it as a specimen of rare seaweed with its centre filled with gold.

Fortunately, nowadays, submarine cables have become so well known that they are not regarded as rare specimens of seaweed, and such causes of interruption are of comparatively unfrequent occurrence.

This accident, however, caused the attention of scientific men to be directed to the discovery of some mode of preserving submarine cables from similar casualties, and it was suggested by Mr. Küper, that the core should be protected by making it the centre of a wire rope. This idea was taken up by Mr. Crampton, who had given much time and study to the subject, and he laid a cable between Dover and Calais in 1851 upon this principle, which worked successfully for many years.

On this board here (pointing to the board) is fixed a large and unique collection of specimens of old cables, which has been lent to me by Mr. Rosenbusch to exhibit before you. I have just shown you the 1850 cable, and here is a specimen of the 1851, picked up in November 1859, with the electrical condition marked perfect, and, as you may observe, the deterioration of the iron sheathing is very slight.

Mr. Küper's happy idea of covering the core with iron wires has held its own until the present day, and we find that the superiority of a line thus manufactured was soon recognised, and several telegraph companies were formed by laying cables upon this principle.

The Holyhead and Howth cable was laid by Newall in 1852; it consisted of a core with iron sheathing, without any intervening lapping of yarn. This cable failed after being down four days.

In 1853, Mr. Webb repaired the Hague cable. This was the first time a cable had been repaired subsequent to immersion, and he then originated the system of buoying and picking up gear.

During the Crimean War Messrs. Newall and Co. laid a cable between Varna and Balaklava, and another from Varna to Constantinople; the former, 150 miles long, consisted of a No. 16 copper wire, with three thin coatings of gutta percha, without any exterior covering; the latter, about 200 miles in length, had also one copper wire for a conductor, but was more thickly insulated with gutta percha, and an armour of iron wires. These lines were laid for the English Government service, and greatly assisted in affording a means of communication with the Crimea, and no doubt helped in lessening the duration of the war. This was the boldest enterprise in submarine telegraphy up to that date. Here is a specimen of the Varna-Balaklava cable (showing it). I believe a specimen of one of these cables was picked up in the beginning of 1878 by the s.s. Chittern while repairing the present Black Sea cable, and that the gutta percha was found to be in good order; that is, after being down some 23 years.

Two attempts were made to connect Sardinia at Cape Spartivento with Africa at Bona by Mr. Brett; the first in September, 1855, and the second in August, 1856, but both signally failed from a want of attention to and full understanding of the mechanical difficulties.

Telegraph companies at this time, and for some years afterwards, seemed to deem it only necessary to have a cable made, and then laid, without a proper regard to the circumstances of the case, such as the depth, nature, and irregularities of the bottom, forgetting entirely the importance of guarding against accidents, and hence the great number of failures. All that the contractors, and those floating the companies, seemed to care about, was to have the cable laid and pass so many messages through it, and then let it take its chance. Fortunately, nowadays, companies are employing experienced electricians and engineers to look after the manufacture, laying, and repairing of their cables, with a keener eye to their longevity.

The credit of laying down the first cable of any length at the other side of the Atlantic belongs to Mr. F. N. Gisborne, an English engineer. He happened to be in London at the time of Mr. Brett's success with the first Dover and Calais cable, and on his return to America, he applied himself to get up a company for facilitating telegraphic communication between England and the United States. Through a mere accident he met Mr. Cyrus Field at a New York hotel, and laid his plans before that gentleman, which ultimately ended, after great exertion on the part of the latter, in his obtaining a concession for, and in the laying of several Atlantic cables.

Mr. Field repaired to England and interviewed several eminent engineers and electricians, amongst whom where Mr. Brunel, Mr. (now Sir Charles) Bright, Mr. Brett, and Mr. Whitehouse, regarding the project, having previously obtained the favourable

* Delivered at the Malta Station to the Eastern Telegraph Company's Staff.

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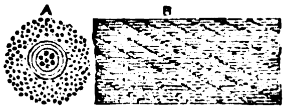
opinion of Lieutenant Maury, U.S. Navy, and Professor Morse, in America. In the first place he tried to connect St. John's, Newfoundland, with Canada and the United States, which attempt unfortunately failed, owing to the expedition being caught in a violent storm. This failure, however, did not in the least damp his indomitable courage, and faith in his larger project of connecting England with America.

In 1856 we find Mr. Field issuing an elaborate, able, and argumentative circular, headed "Atlantic Telegraph." Although a native of America, he received by far the most encouragement in Great Britain, both in Parliament and out of it, and on the 6th of December, 1856, he and his Board were able to enter upon agreements with the Gutta Percha Company for the supply of 2,500 miles of core, and with Messrs. Elliot and Co., of East Greenwich, and Messrs. Newall and Co., Birkenhead, for the supply of the completed cable. One curious thing with regard to this contract was, that one half of the cable was to be made at East Greenwich, and the other half at Birkenhead. The policy of such a division was questioned at the time, for how was it possible that there could be a uniform supervision in the manufacture? The result was one half of the sheathing was twisted one way, and the other half the other. I have here two or three specimens of this wonderful cable, and I append a sketch. You may observe by looking at these two specimens that the lay of the sheathing is in different directions. The cable consisted of—

1st. A central conducting wire, made up of seven copper wires, each wire No. 2 B.W.G. This strand was formed by twisting six of the copper wires round the seventh or central one. This twisted form of conductor was first adopted for the cable laid across the Gulf of St. Lawrence in 1856, and was, and is now, generally employed with a view to the reduction to the lowest possible amount of the chance of continuity being destroyed by the fracture of all the wires at one place.



2nd. The copper strand received three separate layers or coatings of refined gutta percha, which brought its diameter up to about ⅜ inch.

3rd. The combined copper strand and gutta percha, technically termed the "core," was then removed to the cable factories on large drums containing about two mile lengths, and there served with hemp saturated with a composition of pitch and tar. This hempen serving constituted a bed for the external sheathing of metallic wires, and prevented the insulator being injured during the final stage of construction.

4th. The hempen-served core now received a sheathing of *eighteen* strands of bright charcoal iron wire, each strand consisting of seven wires of the same gauge as the copper wires constituting the conductor. The object aimed at in having eighteen strands composed of fine wires instead of eighteen solid wires was to give greater flexibility and strength to the cable. This plan has now been discarded in favour of solid wires. The sheathing received no further coating except that of a mixture of tar and pitch as it was drawn from the machines into the pits in the outer yard, and each layer as it was coiled also received a coating of tar and pitch put on by brushes. The entire length of iron and copper wire used in the manufacture amounted to 332,500 miles, or enough to girdle the earth thirteen times. The cable weighed from 19 cwt. to 1 ton per mile, and was calculated to bear a direct strain of from four to five tons without breaking. Before laying or even completing the manufacture of the cable, the Atlantic Telegraph Company published some most extraordinary principles of philosophy with regard to the supposed capabilities of their cable. These principles are very interesting, although decidedly incorrect viewed by the difficulties which they encountered, and which we even now labour under with our improved forms of apparatus. I shall enumerate a few of them, in order to show you how far we may be misguided without actual trial in the case of a new and untried scientific project, and how careful we should be in making statements as to the capabilities of any telegraphic apparatus or system before it has received a thorough practical test.

Principles of Philosophy Presumed by the Company.—1st. That telegraphic signals could be transmitted without difficulty through the required distance.

2nd. That a large conducting wire was *not* required for the purpose.

3rd. That the communication through the conductor could be effected at a thoroughly satisfactory speed.

4th. That gutta percha covered submarine wires do not transmit as simple insulated conductors, but that they have to be charged as Leyden jars before they can transmit at all.

5th. That consequently such wires transmit with a velocity that is in no way accordant to the movement of the electrical current in an unembarrassed way along the simple conductors.

6th. That magneto-electric current travels more quickly along such wires than simple voltaic currents.

7th. That magneto-electro currents travel more quickly when in high energy than when in low, although voltaic currents of large intensity do not travel more quickly than voltaic currents of small intensity.

8th. That the velocity of the transmission of signals along insulated submerged wires can be enormously increased—from the rate, indeed, of one in two seconds to the rate of eight in a single second—by making each alternate signal with a current of different quality, positive following negative, and negative following positive.

9th. That the diminution of the velocity of the transmission of a magneto-electric current, in induction-ambarrassed coated wires, is not in the inverse ration of the squares of the distance traversed, but more nearly in the ratio of simple arithmetical progression.

10th. That several distinct waves of electricity may be travelling along different parts of a long wire simultaneously, and within certain limits, *without interference*.

11th. That large, coated wires used beneath the water or earth are worse conductors, so far as velocity of transmission is concerned, than small ones, and therefore are not so well suited as small ones for the purpose of submarine transmission of telegraphic signals.

12th. That by the use of comparatively small coated wires, and of electro-magnetic induction coils for the exciting agents, telegraphic signals can be transmitted through two thousand miles with a speed amply sufficient for all commercial and economical purposes.

All these presumptions on the part of the Atlantic Telegraph Company were proved to be sadly at variance with facts (except No. 4 and No. 10) when they came actually to try their powers of transmission and reception with the instruments at their disposal. Who their scientific adviser was in drawing up such a set of statements I do not know, but he must have been sorely puzzled to find practice so very much at variance with his theories.

On the completion of the cable according to the foregoing specified details, part of it was shipped on board H.M.S. Agamemnon, and the other portion on board the Niagara, lent by the United States navy for the purpose.

On the 5th of August, 1857, the shore end of the cable was safely landed at Valentia from the Niagara, and on the 7th the squadron sailed, with the Niagara paying out. After one or two mishaps the cable suddenly broke in 2,000 fathoms of water when about 330 knots had been paid out. It was intended that the Niagara should first pay out her portion as far as it would go, when the cable on board the Agamemnon would be spliced on in mid ocean, and run out to the other shore. The loss, however, proved fatal to the first attempt, and it appeared unwise to renew operations with only 1,847 knots of cable.

(TO BE CONTINUED.)

ON CHARGING AND DISCHARGING CONDUCTORS IN A ROOM.

BY F. C. WEBB, M.I.C.E.

Judging from some remarks that fell from a lecturer at the Royal Institution some months ago, in a lecture on induction,* it appears to me that an experiment which I performed some ten years ago not been sufficiently borne in view. I allude to an experiment with an insulated room, performed in Keyham Dockyard in 1869, and described by me in the *Phil. Mag.* for May 1872. That experiment, I have reason to believe, has been, at least by some persons, considered as a mere repetition of Faraday's experiment, whereas it was quite different. Faraday insulated a room, and showed that, charging it from the outside, no electroscopes or other instruments placed inside showed any signs of disturbance or charging. In my experiment I took the electrical machine inside the room, and showed that all the effects of charging and discharging took place just the same, whether the room was insulated or not, and also that no amount of electrical disturbance inside the room had any effect on an electrometer attached to the room and placed outside. These experiments demonstrated that when a conductor was charged by a machine having the rubber connected to the surrounding objects—at least, when placed in a room—there was no tendency for the negative electricity to flow to and distribute itself in the earth.

The following description of the experiment may be of interest, therefore, to those who have not before heard of the experiment:—

The room was about 8 ft. by 9 ft., and 8 ft. high. The

* See *Electrician*, page 159, Vol. II.

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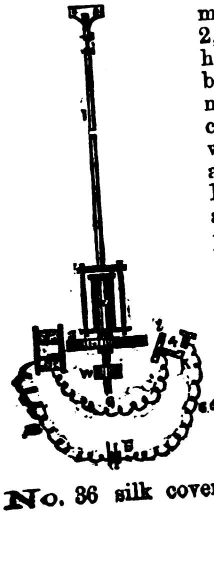
floor was of wood, and the sides of wooden framework covered with calico, and with pieces of tinfoil pasted about it to make it a good conductor. It had a wooden door and two windows of wire gauze. A small table was placed in it, and a frictional electrical machine was placed on this. The room was suspended by four double parts of half-inch-round gutta percha band to a wooden frame, the floor being four feet from the ground. The gutta percha was covered with paraffin, and the whole room was tested for insulation with 500 Daniell's elements, with a delicate astatic Thomson's reflecting galvanometer, and gave no perceptible loss. A Peltier electrometer was placed on the ground outside, and a wire from the brass knob of this was connected to the gauze of the window. The table was connected with the tinfoil that was pasted about the surfaces of the room, so that when the rubber or prime conductor was connected to the table it was in connection with the sides of the room. Thus arranged, the machine acted to all appearance exactly the same as in an uninsulated room. When the rubber was connected to the table, on turning the glass disc, the prime conductor was charged so as to give off sparks the same as when the room was uninsulated, and the conductor was completely discharged when touched to the insulated room. Not the slightest effect was produced on the electrometer, even when sparks were flashing from the prime conductor to the wire gauze of the window to which the wire from the electrometer was attached. Connecting the room to earth made no difference. A sphere about a foot in diameter was then charged when the room was insulated, and then handed out by an insulating handle, when the electrometer immediately diverged to about 50°, showing that the outer surface of the room had become negative. On taking the sphere back into the room, the electrometer fell to zero.

When, therefore, electrical experiments are carried on in a room, it is clear that none of the electricity tends to go further than to the conducting surfaces which bound the dielectric, separating the two equal and opposite charges, and that there is no tendency for the electricity from the pole connected to "earth," *i.e.*, to surrounding objects, to flow away and distribute itself over the remote portions of the earth. Yet this seems constantly lost sight of in explanations of electrical action, and notably in the lectures on induction to which I have alluded.

If we had experiments carried on in the open air it seems to me even then doubtful whether the electricity of the pole connected to earth distributes itself over the earth. It seems more probable that the air at some distance from the conductor forms a body of sufficient conductivity to form a kind of bounding surface for that portion of the opposite charge which is not contained on the conducting surfaces extending to where such charged boundary in the air exists. If a sphere be charged from one pole of a source, the other pole being connected to a pointed conductor, the sphere can be charged, and the opposite electricity must, it would appear, go to charge the air in a kind of bounding strata at some distance from the sphere, beyond which strata neutrality would exist.

A NOVEL ELECTRIC PENDULUM.

For controlling a small turret seconds pendulum clock that has many duties imposed on it (some of them irregular) I have devised and applied a form of pendulum that seems to me to possess some points of interest. It is (suspension excepted) totally free of contact, and consequently of friction, is simple, cheap, and easy to make. The annexed sketch shows the arrangement where—1, is the pendulum rod with mercurial bob *a* and regulating weight W; 2, a bar magnet 6 inches long by ¾ by ⅛; 3, a hollow coil; 4, the contact piece, the magnet *i* being 1¾ inches by ¼ by 1/16, and is delicately mounted on a steel spindle which carries the contact arm K. The magnet and contact arm work stiffly on the spindle for the sake of adjustment; 5, the battery of two very small Minotto cells; 6, the connecting wires. The action is as follows:—On the pendulum completing its journey to the right the magnet 2 attracts the light magnet *i*, closing the circuit, the coil 3 then attracting the magnet 2. The circuit is only closed until the pendulum reaches the vertical (by so adjusting the positions of the magnet *i* and contact arm K), the impulse then ceasing, but it continues its journey to the left until it has accomplished its beat and then swings to the right, again attracting the magnet *i*, and again closing the circuit, and so on. The coil 3 is wound with No. 36 silk covered copper wire of 340 ohms resistance, requiring two cells to keep the pendulum going when not controlling the clock. By using thicker wire one cell suffices, but I prefer a long length of fine wire to tone down any variation in the strength of the battery. So as to avoid any irregularity through variation or loss of magnetism I place the magnet in the magnetic meridian. It also derives, doubtless, a small increment of magnetism at each attraction of the coil 3. After four months working I cannot find any loss of magnetism in either 2 or *i*.



For controlling the clock I adopt Jones's (of Chester) method by placing a small bar magnet in the pendulum rod working into a hollow coil of the same size and resistance as coil 3, and insert it (together with two additional cells) into the circuit 6 *c*.

A pendulum, as above described, has been at work since December last with the same battery, and keeps excellent time.

C. V. de Sauty.

Gibraltar, 22nd May, 1879.

LIST OF DELEGATES SENT TO THE CONFERENCE BY FOREIGN TELEGRAPH ADMINISTRATIONS.

Austria.—M. W. Devez, Postmaster-General; Dr. Brunner von Wattenwyl, Director of Austrian Telegraphs; Count Victor Wimpffen, Inspector-General of Telegraphs; and a Secretary.

Belgium.—M. J. Vinchent, Director-General of Posts and Telegraphs; and M. Gibbs, Chief Inspector of the Telegraph Service.

Denmark.—Captain H. Höncke.

Germany.—Herr Budde, Director of the General Telegraph Office; Herr Gunther, Upper Privy Councillor of Posts; Herr Scheffler, Privy Councillor of Posts; Herr Von Gumbart, Telegraph Director; and Herr Magalle, Secretary of General Telegraph Office.

Great Britain.—C. H. B. Patey, H. C. Fischer, and P. Benton.

Greece.—M. J. Gennadius, Chargé d'Affaires, London.

Hungary.—M. von Koller, Director of Telegraphs.

Italy.—Signor Commendatore, Ernesto d'Amico, Director-General of Telegraphs; and Cav. Berliri, Inspector of Telegraphs.

India.—Col. Champain, Director-General; and Mr. Brasher.

Japan.—M. Yoshikama Akimasa, Head of Telegraph Bureau, and a Chief Secretary of Ministry of Works; and M. Munchiro Nakano.

Netherlands, The.—Mr. Staring, Director of Telegraphs.

New Zealand.—Sir Julius Vogel.

Norway.—Mr. Nielson, Director-General; and Mr. F. Bugge, Inspector.

Portugal.—V. Do Rego.

Russia.—General C. de Leuders, Director-General; and M. P. Salmonwitch, Chef de Section.

Sweden.—Mr. D. Nordlander, Director-General; and Mr. C. Akerlund, Secretary.

Switzerland.—Mr. Frey, Director-General.

Victoria.—Right Hon. Hugh Childers, M.P.

Bureau International.—M. Curchod, Director; and M. de St. Martial, Secretary.

Delegates from the Submarine Cable Companies.

Anglo-American Telegraph Company.—H. Weaver.

Brazilian Submarine.—T. Fuller.

Cuba Submarine.—T. Hughes, Q.C.

Direct Spanish.—C. Gerhardi.

Direct United States.—Captain R. Mayne, R.N.; and J. W. Fuller.

Eastern, Eastern Extension, Australasia, and China.—John Pender, M.P.; Sir James Anderson, Col. Glover, Lewis Wells, and Jules Despecher.

Black Sea.—Julius Beer.

German Union.—Dr. Lovard.

Great Northern.—H. G. Erichsen, Captain E. Suenson, and Captain W. von Hedemann.

Indo-European.—W. Andrews, Dr. C. W. Siemens, F.R.S., and F. Moll.

Mediterranean Extension.—E. A. Tombs.

Submarine.—Sir J. Carmichael, Bart.; Sir J. Goldsmid, Bart., M.P.; Arthur Otway, M.P.; and S. M. Clare.

West Coast of America.—R. K. Gray.

Western and Brazilian.—Major Wood.

N.B.—We have been unable to ascertain the names of the delegates for France, the Indo-European Government Department, and for Servia Spain, and Turkey.

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THE ELECTRICIAN.

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THE REPORT ON THE ELECTRIC LIGHT ON THE THAMES EMBANKMENT.

We are gradually accumulating a series of definite facts concerning the electric light which tend to dissipate the halo of mystery which for a long time encircled the question of electric lighting in the minds of the general public. We doubt, indeed, if we shall ever entirely eradicate from the popular mind the hasty conclusion based upon the opinions expressed more forcibly than scientifically by writers in the political Press. The general excitement of a few months back has given place to another phase in the cycle of changes, which will as certainly be followed by another and perhaps totally different view of the question. At first the electric light was to supersede everything; then it was found that difficulties had to be encountered, and the economy of the general adoption of the light was more than doubtful; so interest gradually dwindled till we have reached the present position. Hasty generalisation is not, as a rule, a failing of the scientific mind. Proofs, decided, unmistakable proofs, are asked for and must be obtained before a decision will be given. The necessary data as regards the electric light are only now being obtained, so that we shall soon be able to give a definite answer to some of the questions that have been asked concerning the light. The report of Sir J. W. Bazalgette and Mr. T. W. Keates, presented to the Metropolitan Board of Works, is of great importance, inasmuch as it gives the results of careful and well-considered experiments. The authors say: "In entering upon this investigation, there appeared to be three main points which offered themselves for our consideration. The first of these related to the motive power to be employed, its cost, and other circumstances concerned in its application to the production of the electrical light; the second, to the electrical machinery proper, to the value of the light as an illuminative agent, and to other conditions growing out of that part of the subject; the third, to the comparative cost of the electric light and gas." The Jablochkoff was the system to be tried, because "no mechanical contrivance is necessary to maintain the proximity of the carbon rods through which the light is produced. Secondly, that there appeared to be, at least at that time, no other system in which so large a number of lights could practically be produced from one dynamo-electric machine as the number then proposed to be lighted on the Embankment. Of course there were many other considerations *pro* and *con*, but those two were thought to justify a preference for the Jablochkoff system for a practical experiment in street lighting." The motive power used was specially prepared and placed at the disposal of the Metropolitan Board of Works—free of charge for three months. Of this the authors remark: "When it is remembered that electric lighting means neither more nor less than the conversion of mechanical force into light and heat, and that the regularity and evenness of the light depends more, perhaps, upon the vigour and uniformity with which that force is supplied than upon any other single circumstance, it will be seen that the basis and foundation of success in an experiment of this kind lies, above everything, in the quality and performance of the steam engine or other motive power which is made use of. In the present case, the engine, which was supplied by Messrs. Ransomes and Co., deserves the most unqualified praise. The principal feature of the engine is, however, an automatic governor of remarkable sensitiveness. The action of this governor rendered the movement of the engine so uniform, that in an experiment of twelve nights the greatest difference in the mean number of revolutions of each night was only 1·12 upon an average of 142·36." It is almost needless to add that the engine proved itself to be of the best construction and worked admirably. Regarding the expenditure of power per light, the report says that with five lamps in circuit the expenditure was 1·59 h.p. per lamp, with ten it was 1·27, with fifteen it was 1·03, and with twenty it was 0·92. The power required to drive the various parts of the engine itself, the shafting, &c.—in fact, the power absorbed over and above that required by the light apparatus—was 5·19 h.p., and, of course, in the calculation this is subtracted from the total h.p. shown when the lights were on, the remainder being the h.p. used by the lights. The cost of working the engine, as regards fuel, oil, labour, &c., per night of 5·5 hours, was £1 9s. 8½d., being at the rate of 3·24d. (nearly 3¼d.) per lamp per hour. The first cost of the machinery was £1,280, which for twenty lights might be reduced to about £990. "This appears to be a fair sum upon which to calculate the amount of interest and wear and tear to be considered in reference to the whole cost of the electric lights as produced on the Embankment."

It is needless for us to refer to the report on the question of dynamo machines, but we quite agree with the authors in thinking it of great importance to know exactly what is the value of the light. On this point the report cannot be too carefully considered. It says:—"A number of experiments were made at the machine-house on the Embankment, where

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a complete photometer was fitted up. These experiments were—1st, upon the naked light; 2nd, upon a light with opalescent globe; 3rd, upon a light with a frosted globe. The measurements were made horizontally in each case. In every experiment the electric light was placed 240 inches from the measuring light, the screen moving between them. Twenty readings or observations were made in each experiment, both with the open and shaded lights. Eight experiments were made on as many different nights between the 27th February and the middle of March with the naked light. Three experiments were likewise made with the light surrounded with the opal globe, and two with the light in the frosted globe. The following are the results obtained in these experiments:—

Naked light, mean of eight experiments..	378·1 sperm candles.
Opal globe „ three „ ...	154·9 „
Frosted ditto „ two „ ...	265·0 „

The loss of light produced by opal glass was therefore equal to 59 per cent.; by the frosted glass only 29·9 per cent. Taking the above figures, it will be observed that the gross output of light from the twenty Jablochkoff candles amounts to 7,562 candles. Nearly 60 per cent. of this is, however, absorbed at once by the opal globes, and, in fact, this is not the only loss; there are two other sources of practical loss, where the chief effect of the light is required to be in a direction downward from the lamp. This loss arises, in the first place, from the greater thickness of the opal glass in the lower third of the globe, and, secondly, from the fact that the most favourable direction for the projection of the light from the Jablochkoff candle is rather upwards, and there is an actual diminution of light horizontally, and more in a downward direction. The consequence of this is that the actual loss of light is, no doubt, much more than 60 per cent., but what the exact loss is we are not prepared to say."

Our space will not allow us at the present time to comment on these various results; that must be left for another opportunity. The report shows that to the above 3·24d. per hour per lamp must be added ·49d. per hour per light for interest on capital, &c., and thus, without considering the cost of the carbon bougies, the total is 3·73d. Since the commencement of these experiments, the company working Jablochkoff's patent have undertaken "to maintain the lamps all round at the rate of 5d per hour per light net—that is, inclusive of the cost of working steam engine, electric machines, and all other current charges. This, according to the figures already given, leaves but a small sum to pay for the candle. It is, however, believed that more work can be obtained from the steam engine; at present preparations are being made for putting forty lights on the engine as it stands, and it is suggested that twenty more may be worked by it; if these ideas prove correct, of course the whole cost of working will be reduced, and the sum which is being paid, viz., 5d. per hour, including all charges, may be remunerative. We can, of course, only deal with the figures which we have before us, and which have been obtained with great care and attention, but in the face of the reduced price per electric candle which the society are now charging, it seems useless to reckon the cost of the candle at the price which the Board paid, viz., 5d. per hour. Taking all the circumstances into consideration, we believe that 2d. per hour for the candle would be a very sufficient charge. We should then have, as the total cost of producing the light, per lamp, per hour:—

Interest on Capital; wear and tear............	0·49d.
Current charge of working engine, &c.......	3·24d.
Cost of Jablochkoff Candle	2·00d.
Total	5·73d."

The report then goes on to discuss the electric light compared with gas, but this comparison, although interesting, is not sufficiently exhaustive to make it of absorbing importance. The authors agree that under "particular circumstances of street lighting, or lighting of great interiors, railway stations or similar places, the electric light will be used; but at present there are defects connected with it that must prevent its adoption as a general mode of lighting competing with gas."

CORRESPONDENCE.

ELECTRICAL ACOUSTICS.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: Would you or one of your correspondents oblige me with an opinion about the following? Not to give you unnecessary trouble, I have asked several electricians for the required information, and also consulted "Ganot's Physics" and other works, but without any satisfactory result. Would the tone of a musical pipe be altered by inserting it into a helix of wire and allowing a current to flow through the coil as though the pipe was the core?

In the celebrated experiment "on the rotation of the plane of polarisation" Biot and Becquerel consider his to be due to a molecular action of the magnet on the transparent bodies submitted to its influence.

Now, if there are molecular changes in substances submitted to the action of powerful electro-magnets, I consider that the air in the tube would be diamagnetic, the change of position of the molecules might influence the sonorous waves, thereby altering the tone. Soft iron tube would probably be the best substance to experiment on, though I imagine the pipe might be made of other material and still produce, under the above conditions, changes in tone. Lastly, change in tone would be a means of communication, as in other instruments.—Yours, &c.,

Raughtra St. Levan, May 29, 1879. J. W. WETHERELL.

P.S.—The enclosed I sent to the *Cornish Telegraph*. Am now making some experiments to compare with the mechanical effects produced by coils, and, if you think the subject of sufficient importance, will forward the results.

[The following is the communication referred to. We shall be glad to receive the results of any experiments.—ED. *E.*]

GLASS PERFORATED BY A SPARK FROM AN INDUCTORIUM, RUHMKORFF'S COIL.

This remarkable specimen was exhibited in St. John's Hall, at "The Davy Centenary." Through the kindness of Mr. Collins, Mr. Ralf, and others, who placed their valuable microscopes at the disposal of the visitors, I was enabled to show the mechanical effects that had been produced by the passage of a spark from a Ruhmkorff's coil, the bobbin of which contained sixty miles of wire. Before entering into a minute description of the above specimen, I think it necessary to say a few words about electrical discharges, for some of your readers may not be aware of the changes that are produced by a spark, or a succession of sparks, passing from various conductors through the air or through a vacuum. Geissler's tubes well illustrate the variety of forms the electric discharge undergoes. By filling a tube with gas, and then gradually pumping it out whilst the spark is passing through, the changes of form may be studied, and these again vary with the particular gas employed. In some cases, it becomes disc-shaped; in others, where the attenuation of the gas is extreme, a luminous ether fills the tube. The colour is also modified by taking the spark from different substances. Mechanical effects are produced by the "inductorium" when the substances are placed between the well-insulated terminals of the coil and the discharge passed through them. Very great care is necessary in the case of non-conducting materials, such as glass, resin, &c., for if the terminals are not insulated by being enclosed in tubes filled with shellac, the discharge will pass outside, air being a better conductor. By passing the spark through a thick piece of glass, we obtain, so to speak, a graphic representation showing the direction, form, and structure, or in other words, the mechanical effect.

Under a powerful microscope, the following structures may be seen:—A transparent undulating tube branching dichotomously by inosculation, surrounded by a delicate spiral fracture, constant in direction and pretty uniform in the number of the turns of the spire. At first sight, one would be inclined to think that the shaded portions were some form of carbon. This, however, is due to polarisation of the concentric structure of which the

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spiral is composed, for, by altering the direction of the rays of light, the most exquisite tints, like in Newton's rings, appear, showing that the dark colour is due to polarisation, or absorption, of the spectrum. Small spherical and oviform bodies may be seen irregularly scattered along the tubes. As, doubtless, the glass is non-homogeneous, this may account for the differentiation of the fracture. Allowance must also be made for induction exerted by the surroundings.

In the mineralogical department of the British Museum, and also in the museum of the Geological Society, specimens of "Fulgurites," or lightning tubes, have been carefully preserved. These are caused by lightning passing through sand, probably to a good conductor, such as a mineral vein, and in its passage fusing or vitrifying the sand. Microscopical examination of the mechanical effects produced by submitting various minerals to sparks from powerful coils might help to determine their molecular structure.

THE THERMO-ELECTRIC BATTERIES OF M. SUDRE.

M. J. M. E. Sudre, who, we understand, is working in conjunction with M. Clamond, has recently taken out a patent, in which the claims are as follow :—

1. The construction and arrangement of thermo-electric chains composed of couples, the resistance of which has been reduced to a minimum, substantially as described.
2. The combination and arrangement of the said chains or thermo-electric couples with two metallic plates of which the opposing surfaces are coated with an insulating layer; which plates form part of two metallic systems, one serving to collect and communicate the heat, and the other to abstract and diffuse it.
3. The combination and arrangement for binding, coupling, and insulating the said thermo-electric chains, when several are mounted side by side between the two aforesaid plates, for constituting a thermo-electric battery substantially as described.
4. The application and use of the collector and diffuser to any description of thermo-electric piles so as to maintain the necessary difference of temperature between the extremities of the couples without lateral waste of heat.
5. The application and use of the different systems of collector and diffuser to the thermo-electric piles substantially as described.
6. The construction and use of the different arrangements of thermo-electric batteries to all of which the above points are applied.

One of the main features of the invention, as described, is the maintenance of the necessary difference of temperature between the two solderings of each couple by placing these couples between two surfaces from which they are electrically insulated. It is stated that "in the construction of thermo-electric couples and chains, an isolated thermo-electric couple is ordinarily composed of a prism in metal or alloy casting (A) and of a polar plate of iron, copper, German silver, or other suitable metal, soldered to each of its extremities. The plates do not ordinarily interfere in the slightest with the electric force obtained, and it is the bar A, such as that of antimony and zinc, which contributes in a great measure to the total effect produced. When it is desired to use two metals or energetic alloys of which the effects are combined, and which are easily fusible, such as bismuth and antimony, the couple is then formed of two bars, A and B, which are joined together by a cross-bar which binds them, and is soldered to each of them."

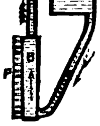
The total resistance of a couple is composed: 1st, of the resistance of the connecting plate; 2nd, of the resistance of the bar A, ordinarily composed of alloys sufficiently resistant, and 3rd, of a particular resistance at the points of contact or soldering between the plates and the bar. The metallic plates should be of a metal sufficiently conductive, such as copper, iron, German silver, &c., and it should be sufficiently large and thick to present but a feeble resistance. It should have also the least length possible. These conditions, it is claimed, are realised in this invention. Again, the bar A should have very little resistance under a small volume. The inventor takes as a datum the formula $R = k\frac{L}{S}$, in which k is a specific co-efficient for the metal employed, L the length of the bar, and S its section. As the resistance depends upon the ratio $\frac{L}{S}$, the volume of the couple may be diminished by diminishing the dimensions in equal degree, in which case the resistance will not be affected. The length which should be given to the bar depends upon the difference of temperatures employed. For differences of temperature between 10° and 120° (centigrade), the inventor gives to the couples a length of 10 or 12 millimetres, whilst, if the higher temperature reaches 300°, the length varies from 20 to 30 millimetres. The resistance at the points of contact, or soldering, is of the highest importance. The junction should be made so that the plate is in contact with the whole section of the bar. The plate should penetrate to a very little depth within the bar, so as not to diminish too much the electromotive force of the couple; for the really effective difference of temperature is that of the two solderings, and this difference diminishes as the plates penetrate more deeply into the bar, and thus approach one another.

In constructing the couples the inventor cuts the extremities of the connecting plates in the form of a comb, the teeth of which are afterwards twisted so as to present a helicoidal surface which holds the plates, as it were, screwed into the bars. The cut portion of the plates is so adjusted in a mould that the teeth become embedded in the bar when this is cast. A considerable number of bars are cast simultaneously, and constitute a thermo-electric chain. The external portion of the plates is coated with asbestos-paper, mica, terra-cotta, or other suitable insulating material, which may be cemented to the metallic surfaces by means of silicate of soda solution, or other suitable cement.

The chains are arranged in battery form between two metal plates, which may be plane or curved. Each of these plates is coated on one of its surfaces with a thin non-conducting layer, which may be of enamel or of mica, if the temperature be elevated, or of vulcanised india rubber or certain kinds of varnish if the temperature be comparatively low. One of these plates constitutes the "collector" and the other the "diffuser."

Various arrangements of the collecting and diffusing surfaces are described. The following figure illustrates the mode of utilising the circulation of water, in order to maintain the diffusing surface at a low temperature.

K is a tank placed at any convenient point, and brought into communication by suitably-arranged pipes with the "cooling-box" (B), of which one side constitutes the "diffusing plate" in contact with one set of alternate junctions in the thermo-electric battery (P). The tank may be filled either with water or with an uncongealable mixture of water and glycerine. The surface of K and of the pipes should be sufficient to diffuse by radiation and contact with air the heat abstracted from P by the automatic circulation of the fluid.



This mode of diffusion can obviously be utilised, in conjunction with the ordinary hot-water pipes, for the heating of buildings.

LITERATURE.

STATIC ELECTRIC INDUCTION.*

As a rule we are so accustomed to think of electric induction as some sort of action at a distance between two bodies, that when we learn that the phenomena of induction are, probably, due to the intervening medium being stretched, compressed, twisted, or somehow deformed, being, in fact, in a state of strain, we see that we have made the same sort of mistake, as if in problems of a spring hanging from a hook and stretched by a weight, we had paid attention only to the hook and the weight, but had ignored the spring. Now, the four lectures recently delivered by Mr. Gordon at the Royal Institution are chiefly concerned with an examination of the behaviour of this springy medium.

Let us first consider the necessity for such lectures, and then examine how far they have satisfied the need for them.

Up to about 1872 we think we are right in saying that no book on quantitative electricity existed in the English language. There were, undoubtedly, numerous accounts of experimental investigations (some few of which were quantitative, but by far the majority of which were only qualitative) into electrical phenomena. The most important of these was, of course, Faraday's *Experimental Researches*. But, although not to be found in text books, there existed, nevertheless, a science of quantitative electricity, a very extensive science, which enabled the telegraph engineer to determine the position of a complicated fault in a telegraph line, the speed of working in long submarine cables, &c., but this science was scattered throughout papers in the transactions of various scientific societies, and was almost inaccessible even to the persevering student, a fact well recognised by all telegraph engineers. In 1868 Sir William Thomson set about collecting his numerous papers on electricity and magnetism, a work com-

* Four Lectures on Static Electric Induction by J. E. H. Gordon, B.A., Assistant Secretary of the British Association. London: Sampson Low, Marston, Searle, and Rivington.

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pleted in 1872; and in 1873 appeared two most important books, very different from one another, and yet having a marked connection, viz., "Electricity and Magnetism," by Professor Fleeming Jenkin, and "Electricity and Magnetism," by Professor Clerk Maxwell. In the former, for the first time in a text book, the student was assumed to know the standard elementary experiments of the lecture room, and he was shown that although we knew as little of the nature of electricity as we did of that of gravitation, still that the mathematical theory of the former was as complete as that of the latter. In the other book all electrical or magnetic actions that have been experimentally observed are made the basis of an exact mathematical development, and, in addition, mathematics are employed in an almost marvellous way to examine the various phenomena that must arise if induction is caused by stresses and strains in the intervening dielectric.

Professor Jenkin's book speaks for itself, appeals to every telegraph engineer, to every student of science, but that of Professor Maxwell is to many practical men an unknown mine of gold, which requires an expositor, a man like Mr. Gordon, and his four lectures which form the subject of this article may be considered as constituting an exposition of some portion of Professor Maxwell's treatise. We only hope, for the benefit of that large portion of the scientific world who, while fully conversant with all the ordinary lecture-room experiments, are ignorant of the mysteries of spherical harmonics, that it may accord with Mr. Gordon's plans to continue his explanation of what the higher mathematics has enabled the divining mind of Professor Clerk Maxwell to accomplish in his "Electricity and Magnetism."

The first of the lectures is confined almost entirely to a repetition of the well-known experiments illustrating the existence of positive and negative electricity, and the difference between conduction and induction. But it is from no fault of his own that Mr. Gordon is not able at once to plunge into the newer portions of his subject, and so, by dwelling longer on the matter that formed the subject of his last two lectures, have made the course of even greater value to the scientific reader. That he was unable to do so arises from a certain amount of incongruity that must accompany all lectures delivered at the Royal Institution. The lecturer is anxious to develop before his audience some new theory or new experiments, but custom compels him to spend much time in going over preliminary matter, such as forms the subject of the lectures at an elementary class at a college. This is, of course, not intended for those of his audience who have had a scientific education, but we doubt whether it is possible, for the benefit of those who have not, to condense the education of years into two or three hours, so as to enable them to grasp the important facts and theories given at the conclusion of the lectures. But thus heavily weighted, as we consider a man is who lectures at the Royal Institusion, we think Mr. Gordon has done remarkably well in giving us so much real information.

On page 27 we notice a slight error in an illustration, in depicting as negatively charged the *outer* surface of the earth coating of a Leyden jar charged by induction from the inside. Trifling as this is, we notice it, because it is the sole error we could find in the book.

The commencement of the second lecture is concerned with the most important analogy between the residual charge in a Leyden jar and the absorbed strain in a viscous body under stress. Mr. Gordon showed how the recovery, after relief, of a bent strip of gutta percha agreed with the discharge of a Leyden jar, in that both show the phenomenon of the "soaking out" of an absorbed charge. There is also another most interesting analogy that may be added, viz., that just as a bent spring let go sharply passes the equilibrium position and oscillates for some time backwards and forwards about it, so, in certain cases, when a Leyden jar is discharged through a wire there are waves of electricity in alternate directions, the differential equations of the motions in the two cases being identically the same. This explanation Sir William Thomson has suggested may account for the darting backwards and forwards called forked lightning.

The lecturer then proceeded to show the orthodox experiment considered to prove that electric induction takes place in curved lines, viz., that a metallic screen which prevents the rays of light, which diverge from a point A on one side of it, from illuminating a point B on the other, allows in certain cases an electrified body at the point A to act on another body at the point B. But we venture to suggest that this experiment is susceptible of a totally different explanation. On the metallic screen electricity is induced which acts on all other bodies like any other charge of electricity, and it is the combined action of these two charges which affects every point, and makes the lines of force curved. A metallic screen for electricity is something like opal glass for light, which, while it allows some of the rays to pass through, absorbs the rest, becoming thus self-luminous, and consequently able to illuminate points which could not have been illuminated by the source of light direct without the opal glass. In the same way a non-conducting sheet for electricity is like transparent glass for light. But we think it can no more be said that the lines of electric induction are curved than it could be said that because an opal globe diminishes the shadows cast by a single bright luminous point the rays of light are curved. Valuable, indeed, as are lines of force, we think too much importance may be attached to them in regarding them as real. Are they, for example, more real than the sort of spiral path of the moon due to the gravitation attractions of various bodies and of its initial velocity. Because that path is a curved one, we do not consider that any one of the attractions acts above a curved line. But although this comment may be regarded in the light of an objection, it must be remembered that it is the clear and suggestive way in which Mr. Gordon's experiment is described that has enabled us to make it.

We next come, in Lecture III., to specific inductive capacity, illustrated in Faraday's home with Faraday's own apparatus. The apparatus used by that philosopher was rough, but the results were not, and where in some instances results have been obtained at variance with his conclusions it must be remembered that while his theories were developed by thought, his conclusions were the result of experiment; so that it is to be expected that, subsequent experimenters, having instruments thousands of times as delicate as those at his disposal, and all the light which intervening years have thrown on the results discovered by himself, will ascertain facts contrary to his experimental conclusions. The wonder is not that Faraday left some things for other people to discover, but that he was able to ascertain so much.

In this third lecture we come to the real interesting part of the course, the account of the author's own experiments on specific inductive capacity and the results obtained from them. After mentioning the great importance of an accurate knowledge of specific inductive capacity to the telegraph engineer in connection with the speed of working long submarine cables, he goes on to give the reasons for his undertaking these experiments. We give them in his own words, "Every new investigation which is made points to a close connection between electricity and light. The theory of their connection requires a certain relation between the specific inductive capacities and certain optical properties of transparent bodies. This theory, which may even tell us what electricity is, can only be tested by an accurate knowledge of the specific inductive capacities of transparent bodies.

"The great difficulty which all previous experimenters have met with was to make the experiments quickly enough. If the electrification is allowed to continue for even 1-100th of a second all sorts of effects come in which are not due only to the specific inductive capacity of the insulator.

"Three required conditions were before us when the new apparatus was being designed.

"1st. The experiments must be made very quickly. This was accomplished by reversing the electrification 12,000 times per second, so that the duration of each charging of the insulator was only 1-12,000th of a second.

"2nd. The electrified metal plates must not touch the insulators. When they are allowed to do so it is found that there is a leakage through the insulator which affects the results.

"3rd. The method must be a zero method."

Mr. Gordon then gives a full and clear account of his apparatus and experiments for fulfilling these conditions. The table of specific induction capacities on page 90 is most interesting. First, we notice that the results for glass are all higher than 3, instead of being less than 2, as is usually supposed; secondly, that the number for solid paraffin is almost exactly the same as obtained by Messrs. Gibson and Barclay; thirdly, that the numbers for india rubber, gutta percha, &c., are all much less than is usually found in text-books.

During the last five years there have been three important determinations of the specific inductive capacities—the first by M. Boltzmann, the second by Dr. Hopkinson, and the third by Mr. Gordon. The peculiarity of M. Boltzmann's method of experimenting consisted in the dielectric under examination not touching the electrified metal plates; but his results, instead of being lower than the previously-determined numbers, as might have been expected from the possibility of ordinary conduction having been in his investigation prevented, were all higher. The reason of this M. Boltzmann considered to consist in the difficulty experienced by previous experimenters in accurately determining the exact thickness of the solid dielectric when it was in contact with the induction plates. Dr. Hopkinson's experiments were confined entirely to different kinds of glass, the glass sometimes touching both electrified metal plates and sometimes only the lower one on which it rested. His results vary between 6·6 and 10·1, the lowest, for flint glass, being nearly four times as great as the result originally obtained by Faraday for the same kind of glass. What was the

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cause of this? Dr. Hopkinson found no great difference whether the dielectric was touching both metal plates or only the lower one on which it rested, a result similar to that obtained by M. Boltzmann, who also observed that duration of electrification made little difference, his shortest time being, however, probably a considerable fraction of a second. The explanation cannot, therefore, be found in the mere fact of the dielectric touching or not touching the metal plates, or in the difference of time of electrification, provided, of course, that this time was far greater than that employed by Mr. Gordon in his experiments. Can it be possible that the specific inductive capacity of certain dielectrics is a function of the difference of potentials to which the condenser is charged, the capacity diminishing somewhat as the electromotive force is increased? If this were the case a sort of explanation would be furnished since, while M. Boltzmann and Dr. Hopkinson used ordinary batteries of Daniell's cells, Faraday used frictional electricity. To a certain extent this idea, which we are not aware has been suggested before, is borne out, seeing that in the case of light flint and of triple dense flint glass, for both of which Dr. Hopkinson tried forty-eight cells and seventy-two cells, the results obtained were in each case about 2 per cent. less with the larger battery than with the smaller. But, of course, it is very probable that this effect may have been due to some other cause, and that the charge is directly proportional to the electromotive force, seeing that the deflection of a loaded beam, which bears so close an analogy with the charge in a Leyden jar, is so nearly proportional to the load, which corresponds with the difference of potentials on the two sides of the dielectric. Mr. Gordon used an electromotive force of about 2,000 silver chloride cells, and his numbers for the specific inductive capacity, while higher than those of Faraday, who used frictional electricity, are lower than those obtained by M. Boltzmann, Dr. Hopkinson, and the various electricians who have experimented on gutta percha and india rubber telegraph cables, using much smaller batteries. It would be extremely interesting to learn how the specific inductive capacities, determined with the same materials, the same apparatus, and using various electromotive forces *without reversal* would agree with, or differ from, those Mr. Gordon has already found.

Again, if the smaller numbers are due to the rapidity of the reversals, and not to the magnitude of the electromotive force what is the longest period of electrification that can be allowed without increasing the capacity? We understand Mr. Gordon is at present carrying on his researches, so that we may hope he will shortly solve these questions for us.

His fourth, and last, lecture is concerned with a most interesting examination of the connection between light vibrations and those of electro-magnetic induction. He explains how the velocities of the two wave transmissions in air, in his own double extra dense flint glass, and in paraffin wax, have been proved experimentally to be identically the same within the limits of error of the experiment. He describes Dr. Kerr's experiments, and in repeating the experiment, obtains a new phenomena, when the strain of the glass through which the polarised light is passed becomes intense just before fracture. Assuming that charging a body is the same as straining the adjoining dielectric, then we might expect that the liquid in a voltameter, of which the platinum plates are at a little less difference of potentials than will decompose the liquid, would be in a state of great strain and would act on a beam of light passed through it; curiously enough this experiment, which has the advantage that we can adjust the electromotive force so that the strain is always just bordering on rupture, has, so far as we are aware, never yet been tried.

From what has been written it will be seen that Mr. Gordon's little work will form a very valuable introduction to the ideas of electric induction developed in Professor Clerk Maxwell's treatise.

MULTIPLE TELEGRAPHY.

At the Royal Institution, on Monday, May 26, Mr. W. H. Preece delivered a lecture on Multiple Telegraphy, of which the following is an abstract:—

Many of you, in your rural rambles, may, during a moment of reflection or thoughtlessness, while standing on the parapet of a rustic bridge, have dropped a stone into the river flowing below, and have noticed the rings of waves projecting outwards. If at the same moment a hungry fish, in his desire to satisfy a natural craving, should dart or snatch at a fly on the surface of the water, a second series of rings of waves would be produced, and in such a case a careful observer would notice that where crest of wave meets crest of wave there is a higher crest formed, and where hollow meets hollow a deeper hollow is formed. This super-position of wave on wave is called interference, and the interference of undulations plays a most important part in the phenomena of sound, of light, and of electricity.

In electricity, wave upon wave can be super-imposed, either in waves flowing in the same direction or in waves flowing in opposite directions. The usual indication of the presence of electric waves is either by the attraction of a magnet or by the deflection of a needle.

Here is a needle that is subject to the action of the passage of such waves of electricity. I send a current of positive electricity through the wire surrounding the magnet to which this needle is attached, and you see I get a certain deflection; I increase the strength of that wave by super-imposing another wave, and you see I increase the strength of the deflection. In the same way, if I reverse the direction of the current and send a negative current, I get a wave of certain strength, and if I double the strength of the current I get a stronger deflection. But if, instead of super-imposing one wave on the other in the same direction, I send one wave in one direction and another wave in the opposite direction, we get neutrality. This neutrality is a phenomenon corresponding very much to silence in sound or to darkness in light.

Advantage is taken of this neutrality in duplex and quadruplex telegraphy, in a way in which I will show to you. It is usually imagined by those who think of duplex telegraphy that something crosses or passes in the same way that railway trains pass or cross each other. It is not at all necessary to conceive that anything whatever passes. For instance, here I have some glass balls placed in a row between two parallel wooden rods. If I take the ball at one end, say No. 1, a short distance from its normal position, and drive it along the rods back again, you will notice that a something, a form of force, passes through the other balls, and the one at the far end is by this developed motion forced a distance away from its neighbours. The same thing occurs if I take No. 12, No. 1 is displaced by the concussion. This resultant motion represents, and may be called a telegraphic signal. If I am skilful enough to take No. 1 and No. 12, and let them return together, we shall see that they are both driven back simultaneously, the intervening balls remain undisturbed, and two such signals will be made. It is this latter phenomenon that I wish you to bear in mind as being analogous to the principle used in duplex telegraphy.

The next fact that I wish to impress upon you is that if a current of electricity have many paths open to it, it will always separate or spread itself among those paths in inverse proportion to the resistance which each opposes to its progress. The greater the resistance the smaller the current; the less the resistance the greater the current.

If we have two paths or lines open to a current, and these two lines be of exactly equal resistance, the current will divide itself between them in exactly equal proportions.

The next point, almost as self-evident as the previous one, but which time will not allow me to illustrate by experiment, is that the magnitude of the magnetism produced in the electro-magnet is simply proportional to the strength of current passed through the magnet.

The next and last elementary fact I have to bring before you is that the polarity or direction of the magnetism simply depends upon the direction of the current.

On the wall I have two electro-magnets corresponding to each other. Around each are coiled two wires of exactly equal length and equal resistance. If I send a current through one of the wires I produce a deflection in one direction; if I send a current through the other wire I get a deflection in the opposite direction. You can imagine that one of these magnets is in Brighton and the other in London, with the connecting line wire between them. I want to arrange matters so that when I make a signal at Brighton I shall not in any way affect my own instrument, and to do so I divide my current in halves; one half goes through one wire of the magnet, and tends to deflect the needle in one direction, and the other half goes through the other wire of the magnet, with a tendency to throw the needle in the opposite direction. If by an arrangement an artificial line or otherwise, I make these two halves exactly equal, no deflection of my needle takes place; but at the same time I do influence Brighton's needle. This gives us the first principle of duplex telegraphy. Of course, with a similar arrangement at Brighton, on the key at that end being depressed and a current divided in half sent through the electro-magnet, the needle there remains unaffected, while at the same time the needle at this end is deflected. Under these conditions, when currents are sent from both instruments signals or deflections are noticed at each station. It is by using resistance that we are able to make an artificial line attached to the second wire of the electro-magnet exactly equal to the line wire attached to the other wire of the electro-magnet. I have in a box here resistance equal to three or four hundred miles of line. Resistance is measured in ohms, an ohm being a unit used by

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electricians, and which represents about a yard of fine platinum wire, or about one-tenth of a mile of ordinary iron wire. The resistance contained in this box is divided into quantities ranging from one to two thousand ohms, any portion of which can be brought into use by simply taking out pegs representing the amount required. With this ready means at hand you will easily comprehend the facility with which a balance can be adjusted, and the opposition to the two halves of the current passing through the electro-magnet made equal. Whatever the distance of the line, whether between here and the Central Telegraph Station, or between here and Calcutta, or any distant place to which you choose to exert your imagination, the effect is just the same. To show you this system in actual working I have here instruments joined to a wire which passes through the streets to the Central Telegraph Station in the city. It is just as easy for us to connect a wire up in actual operation as to have assistants secreted in the adjoining room, which is sometimes supposed to be the case. I must first of all explain to you how telegraphic signals are interpreted into ordinary language. It is by means of what is known as the Morse alphabet, which consists of combinations of dots and dashes used to represent the ordinary letters. A dot and a dash, for instance, represent *a*, a dash and three dots represent *b*, dash, dot, dash dot *c*, and so on throughout the alphabet. A dot itself is represented on the instruments before us by a short sound or beat, and a dash by a longer one. The sounds caused by the signals appeal to the consciousness through the ear, and are translated into the proper language. (The central station was called up, and a message was sent to him at the same time that one was being received from him, in illustration of duplex working.)

The operation which you have just seen going on exactly corresponds with that which I just described to you. The division of the current is arranged at each end by the use of a resistance box or "rheostat," and signals are sent without any interruption the one with the other.

The duplex system of telegraphy is employed to a very large extent in this country, no less than 320 circuits being so fitted. The system is applicable to long and short lines, and even long cables in the Red Sea, Indian Ocean, and across the Atlantic (in one case 2,400 miles long), have been successfully so fitted.

Its application enables really more than double the amount of work being done to that which the wire (if an ordinary land line) performs when working singly. This happens from the fact that no interruption arises from repetitions being required or questions asked, but the messages pass in a continuous stream in opposite directions almost without let or hindrance.

I would just mention another thing in answer to any who are surprised at errors taking place in the transmission of messages. The signals representing certain letters are very similar, and it is very easy for a faint dot to be missed or a short dash to be misinterpreted for a dot, and as the difference between the letter *t* (represented by a dash) and *r* (represented by a dot, dash, dot) is simply two dots, you will not be surprised at a message, informing some friends of the arrival of a party of ladies, "all right" was delivered as "all tight." And, again, a friend of mine in Manchester, whose wife wished to inform him that the "rash was all gone," was astonished to receive an intimation that the "cash was all gone." Many of these errors are simply due to the failure of a dot or the shortness or breaking of a dash, and the wonder is that with the more than one hundred million messages which are despatched every year in this country the percentage of errors is not greater than the small amount it is. I hope that, after the practical illustration you have just had of the extreme care and exactitude which is attendant on the accurate receipt of signals, you will deal lightly with errors of conversion of words such as "rash" into "cash," "right" into "tight," &c.

So far as regards duplex telegraphy.

We now have to deal with another class, and that is called diplex telegraphy. Duplex telegraphy means sending two messages in opposite directions at the same time; diplex means sending two messages at the same time in the same direction. I have here two little instruments which give out their signals in musical tones, and I have also two keys attached to a battery in connection with them. There is only one wire between them. If I press down, say, key No. 1 I call up the sounder which emits a deep tone; if I press down key No. 2 I obtain a response from the sounder with a tone an octave higher. If I press both keys down at the same time both sounders answer, and whichever key is depressed it is always answered by its proper sounder. This power of sending two signals or messages at the same time in the same direction is called diplex telegraphy.

It is difficult to explain how this is performed without the aid of a diagram, and it really requires some amount of courage to attempt the feat. Currents of electricity are developed in two ways; they differ in the direction in which they flow and also in their strength.

The key on my right hand simply reverses the direction in which the currents flow every time it is depressed; the other key simply increases the strength of the current flowing, whatever may be its direction. A relay is also employed which responds to a reversal of the current whatever its strength may be, and another relay responds to the increased strength of the current whatever its direction may be; so that on depressing the key to which the deep-toned sounder responds I send say a positive current; and if I touch the light sounder key I simply make that sounder speak by increasing the strength of that current. The same effect would be produced if I first sent a negative, and caused one sounder to respond, and then by increasing the strength of that negative current the other sounder would respond. The one relay is affected only by a strong current, while the other relay is affected by a strong or weak current, and is, therefore, influenced by either strong or weak reversals. (Mr. Preece here very minutely traced the different currents from the battery through key and relay to sounder, so as to produce sounds by currents, varying in either direction or strength, and acting upon one or both sounders at the same time, or separately at will). The increase of current was brought into action by means of the one key having attached to it a greater proportion of cells of the battery.

That is diplex telegraphy.

How is this diplex used for quadruplex working? I showed you in diplex working that we simply split the current in two paths made exactly equal to each other. It matters not whether we have one or any number of relays in. Theoretically, it is possible to insert a great number of relays, but practically only two are used; and in quadruplex working we simply duplex what I have called the diplex arrangement. On one end of the table before you we have two sides of the quadruplex, or one diplex; and on the other end of the table we have the other side of the quadruplex which also works diplex, and by this apparatus we are able to send four messages at the same time on the single wire, which you see goes from the table to the wall, and so proceeds to the Central Telegraph Station. (The various courses of the currents and adjustments of balance necessary, chiefly owing to variations of temperature, &c., were here described, but without the aid of a diagram it would be next to impossible to follow them.) The system, although difficult in description, is really wonderfully and beautifully simple, and if it were only requisite to follow out what I have just said, quadruplex working would be a very easy matter indeed. But there is such a thing in England as a climate, and there also is unfortunately such a thing as rain, and rain interferes very considerably with the action of our duxplex and quadruplex working. In a word, the effect of rain is precisely the same as reducing the length of our line. Supposing we have a wire between Liverpool and London, about 200 miles long, then when we have rain it covers the insulators with moisture, and the moistened insulators allow the current to escape to earth, and the result is just the same as though the line itself were reduced in length; and to compensate for this it is necessary to take out resistance equal to the loss. But by means of the rheostat it is not a very difficult matter to adjust a balance, and by carefully noting and watching storms of rain, snow, sleet, or fogs and mist, which are so troublesome to the working, a clerk has simply to vary his rheostat, and can so maintain working on wires of ordinary length.

When we come to very long lengths of wire the weather disturbance interferes very much.

There is another disturbance besides that produced by rain or weather, and that is one due to the existence in a telegraphic line of what is called electrostatic induction. This is a very hard word, but it really means something similar to the effect of friction in pipes on the flow of water or gas. When gas or water is forced through pipes, a quantity of it adheres to the sides, and produces a diminution of pressure due to friction. So, when we try to force electricity through a wire, a quantity of it adheres, as it were, to the sides of the wire, remains there as a charge, and diminishes the action of the current, and produces what is called retardation in signals. Retardation means really reducing the rate at which we work. If it is possible, say, between London and Aberdeen to work as fast as ever we like, when we attempt to work over a long submarine cable the speed diminishes very greatly indeed. Between London and Cork, and between London and Aberdeen we are at the present moment working practically as fast as the instuments will run, at the rate of about 150 words a minute, while through the Atlantic cable, with all their skill, they cannot work at more than twenty-five words a minute, and this is due to the disturbing element of electrostatic induction. To compensate for this it is necessary to make your artificial line exactly similar in all respects to your real line, and, with

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duplex circuits, this is done by inserting, in addition to the rheostat, a condenser. A condenser is simply a series of leaves of tinfoil separated by paraffined paper. A series of alternate paraffined papers and tinfoil really comprise a Leyden jar, and such a Leyden jar would have the capacity of retaining a charge similar to that retained by the line; and it is only necessary to increase the size of the condenser until the same electrostatic capacity in it is obtained as is experienced in the line itself. Here is a condenser which has not the appearance of being a very formidable instrument, but it has sufficient electrostatic capacity to compensate for a line about 200 miles long.

We will now work the quadruplex apparatus before you. I do not hope to have made you comprehend the action of the system; I only hope that I have given you an idea which you can work out for yourselves, and which will give you more interest in seeing the system in actual operation.

(Communication was then opened with the Central Telegraph Station, and several messages were sent to and from the Institution on the quadruplex apparatus.)

Many people are suspicious of operations of this kind going on at lectures. I may tell you that a few years ago I gave a lecture at Southampton, and took special care to have a wire joined through London to the Continent (we only had one cable at that time), and at the proper period of the evening spoke to London, Vienna, Berlin, and Amsterdam, and received answers. I then asked what time it was in Vienna (it was nine o'clock in Southampton), and received answer, "Twenty minutes past eight." This was wrong, and it turned out that a clerk in London had been personating the Continental places, and knowing that there was forty minutes difference in the time he put it on the wrong side!

We have in England at the present moment six circuits worked with this system. In America the system is carried out to a much larger extent, and sixty-three wires are fitted with it, and over these sixty-three circuits no less than eight million messages are transmitted annually.

The question may arise in your minds as to why the quadruplex apparatus is not used as extensively in this country as in America, and the answer would be that in this country we have not the necessity for it. We have apparatus in use superior to the quadruplex. I mean the Wheatstone automatic, an instrument which was in its early stage brought before an audience of this Institution. It enables us to transmit messages and news with enormous rapidity, and makes us quite independent of any of those supposed advanced inventions.

What has transpired before you this evening is simply one of the innumerable applications of electricity that are now daily in use, and it really makes us regard with wonder what science is doing for us. What you have just seen far exceeds the dream of the wildest alchemist, and the most imaginative necromancer never could have conceived the possibility of four persons talking to each other at the same time separated by a distance of 200 miles; but when we assail Nature in her strongholds it is astonishing to find how easily she is mastered, how simple are the means by which she veils her secrets, and how rude are the weapons she places in our hands to produce before you these wonders.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices June 4.		Business Done Week Ending June 4. Highest.	Lowest.
Anglo-American	56,	¼	56	55¾
Do. "B"	85½,	¾	85¾	85½
Do. "A"	27¾,	28¼	28¼	27¾
Brazilian	7,	¼	7⅛	7⅛
Cuba	8½,	¾	—	—
Do. Ten per Cent. Preference	16,	17	16⅞	16½
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	10½,	11	11	11
Direct United States	10⅝,	11⅛	11	11
Eastern	7 11-16,	13-16	7¾	7 11-16
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	101,	103	102⅞	101
Do. Six per Cent. Preference	11¾,	12	—	—
Eastern Extension	7⅝,	⅞	7 13-16	7 11-16
Do. Six per Cent. Debenture	107,	110	—	—
German Union	7¾,	8¼	8¼	8¼
Globe Telegraph and Trust	4¾,	5	5	4 15-16
Do. Six per Cent. Preference	10 15-16,	11 1-16	11	11
Great Northern	8⅝,	⅞	8 13-16	8¾
Indo-European	20,	21	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's ex div.	9,	10	—	—
Submarine	225,	235	228	226
West India and Panama	1¼,	¾	—	—
Do. Six per Cent. Preference	7½,	8½	8 1-16	7 15-16
Western and Brazilian	3⅝,	⅞	—	—
West. Union Seven per Ct. 1st Mt.	112,	116	—	—
Do. Six per Cent. Sterling	103,	106	—	—

TRAFFIC RECEIPTS FOR MAY, 1879.

Companies.	May 1879.	May 1878.	Increse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	—	—	—	—
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	15,970	—	—	—
Eastern Extension Telegraph Company	25,845	23,844	2,001	—
Eastern Telegraph Company	38,371	33,650	4,721	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

We have received, too late for insertion this week, a letter from Mr. J. B. Stearns in reference to the letter of Mr. J. Muirhead, jun., on Duplex Telegraphy, in our last issue.

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J. P. BEDFORD, *Secretary, pro tem.*

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NOTES.

Great Northern Telegraph Company.—We are notified that the Siberian land lines are restored, and the communication by this Company's route with China and Japan is, therefore, again perfect.

Brazilian Submarine.—The directors of the Brazilian Submarine Telegraph Company (Limited) have declared an interim dividend of 2s. 6d. per share, or at the rate of 5 per cent., free of income tax, for the quarter ended 31st March, 1879, and payable on Tuesday, the 24th inst.

Utilisation of the Energy of Fuel by means of Steam.—According to M. Tresca, speaking at the recent conference at *la Sorbonne*, 1,100,000 horse-power is utilised in France alone. This power represents that of 14,000,000 of men—that is to say, of a population much greater than the number of working men in the country. The manual labour accomplished by machinery must have the effect, said the speaker, of enabling men to devote themselves to intelligent work.

Temperature of the Voltaic arc and of the Electrodes between which it is formed.—At a recent meeting of the *Société de Physique*, the secretary read a letter on this subject from M. Rossetti, professor at the University of Padux. By measuring the amount of radiation, he found, in the case of a light produced by eighty Bunsen elements, that the temperature of the arc was 3,500° Cent., whilst that of the positive pole was 2,870°, and that of the negative pole 2,400°. These temperatures decreased as the number of cells was diminished.

St. Petersburg.—The Special Telegraphic Commission, says the *Daily News*, recommends a large extension of lines throughout the Empire in three classes. The first class, 21,340 versts and 410 stations, to be finished in five years, at an outlay of 840,000 roubles yearly; the second class, 16,485 versts and 129 stations, costing 2,260,820 roubles; and the third class, 12,822 versts and 90 stations, at an outlay of 4,853,950 roubles, for completion as found practicable. The lines are very distant, little used, but important for the Government.

Gilding on Steel.—An old process—which, however, is by no means universally known—is as follows:—By shaking a solution of gold leaf in aqua regia with ether, or naptha, the gold will leave the acids to combine with the other liquid. Polished steel surfaces, such as knives, scissors, &c., on being plunged in this solution, when dry become covered with a coat of gold, which is an excellent preservative from rust. Letters, designs, &c., may be traced by means of a pen, pointed stick, or brush, and as the ether evaporates, the gold will remain fixed.

Incorporation of the Edison Telephone Company.—The Edison Telephone Company, of Europe (Limited) says the *Engineering and Mining Journal*, filed articles of incorporation on May 20, the incorporators being Thomas A. Edison, Robert L. Cutting, Robert L. Cutting, jun., S. S. White, and James H. Banker, who are also trustees for the first year. The company is to continue 20 years, the capital being 100,000 dollars, divided into 1,000 shares, the par value being 100 dollars each. The business is purchasing and owning, using and procuring to be used in Europe and elsewhere inventions in or relative to speaking telephones.

International Telegraph Conference.—All the delegates, with ladies and friends, numbering about 150, will visit the Crystal Palace to-day, and, after hearing the great rehearsal of the choral music to be performed at the fête to the Duke and Duchess of Connaught, will be entertained at dinner by the Conference Reception Committee, at which Mr. Thomas Hughes will preside. On Tuesday, the 17th, the delegates are invited to a dinner at the Freemason's Tavern by the joint Reception Committee of the Post Office and the Telegraph Companies. On Wednesday, the 18th inst., the Society of Telegraph Engineers issues invitations to a *conversazione* at South Kensington.

A Church at Wrexham Struck by Lightning.—A fearful thunderstorm broke over the town of Wrexham about half-past three on Sunday last, during which the spire of St. Martin's Church was struck by the lightning. At the time of the catastrophe Mr. Aspinall was conducting a class in a room at the base of the spire. He was knocked down by the lightning, and his trousers split, but luckily escaped without any further injuries; but we regret to say that five of his scholars were burnt, three of them so severely that they were carried to the Infirmary at once, and one had his leg broken. There were a number of ladies conducting classes in another part of the church who were so alarmed that they fled through the rain, leaving hats, cloaks, bonnets, and umbrellas behind them.

Effect of the Electric Light on the Eye.—Prof. Cohn, of Breslau, has been making experiments with the electric light on the eyes of a number of persons for the purpose of testing its influence on visual perceptions and sensations of colour. He has found that letters, spots, and colours are perceived at a much greater distance through the medium of the electric light than by day or gas light. The sensation of yellow was increased sixty-fold compared to daylight, red six-fold, and blue two-fold. Eyes which could with difficulty distinguish colours by day or gas light were much aided by the electric light. Professor Cohn concludes with his opinion that the electric light would prove exceedingly useful in places where it is desirable that signals should be seen at a great distance.

Post Office Telegraphs.—A report of the Treasury officers of accounts on the subject of certain representations made to the Treasury respecting the purchase by the Post Office of the undertaking of the United Kingdom Electric Telegraph Company (Limited) has been issued as a Parliamentary paper. The representations set forth that the amount paid to the company was "illegally obtained by misrepresentations to the Government;" that "it is manifest that the revenues of the country have been unjustly appropriated;" and that the revenue of the country has thus "been defrauded of over £400,000." The amount paid under the award was £562,264 9s. 11d., the total amount claimed by the company being £783,717 6s. 11d. The company were entitled to payment under several heads, which were separately specified in their claim, but the arbitrators awarded a

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total sum, without apportioning it under those heads, and no details of the total award are therefore on record in the Post Office. The Treasury officers are satisfied that the payment by the Government to the company was not based upon any misrepresentations, and that the award of the arbitrators was strictly legal.

Solution for Recoating Plated Goods.—The following recipe is, we believe, somewhat extensively employed. It is, we should think, better calculated to prepare the goods for *sale* than for long-continued *use*. We should prefer to "strip" the articles, and to electro-plate them afresh:—" One pound of powdered and highly dried carbonate of soda is to be mixed with 10oz. of flowers of sulphur in a crucible, or pipkin, and heated gradually over a slow fire till the sulphur melts. This mixture is to be stirred about for some time, dissolved in a quart of water, and filtered. The filtered solution is to be boiled as soon as possible with some more flowers of sulphur, and filtered again. Should any crystals appear on cooling they must be redissolved by the addition of fresh water. Hyposulphite of soda is thus formed, in which a precipitate made as follows is to be dissolved. Make a strong solution of nitrate of silver (lunar caustic) in water, to which a solution of common salt is to be added as long as any sediment is produced. This sediment is to be separated by filtering through blotting paper, well washed with water, and afterwards dissolved in the solution of hyposulphite of soda described above. Dip the article to be plated in the liquid or apply with a brush."

A Home-made Daniell Cell.—The following method of constructing a voltaic couple may be of interest to the student:—Select a small round earthenware jar, such as is used for keeping preserves, and having lined the bottom with gutta percha, or some suitable cement, to the depth of $\frac{1}{4}$ inch, fix upright in this a rod of zinc, of equal height with the jar, to which a length of copper wire has been attached by passing it through a hole drilled in the upper part of the zinc rod, or by soldering. Make a cylinder of pipeclay, or other porous clay, larger than the zinc rod, and having dried it, make it hot in the fire by degrees, till it attains a red heat. Let this cylinder cool gently, and when cold, place it in the jar round the centre rod, encircling it at a little distance. By moderately heating the end of the cylinder, it will, when placed on the gutta percha, make a groove which will fix the tube, and prevent infiltration of the fluids. Line the inside of jar with a plate of thin copper bent into a cylindrical form and having a few holes punched in it, through which may be threadled the extremity of another length of copper wire. On the top of this cylinder place a flat ring of copper pierced with holes, and nearly, but not quite, touching the porous cylinder. This forms the battery. To charge it, a saturated solution of sulphate of copper is poured between the copper and the clay tube, and some crystals of the same salt are placed upon the perforated ring so as just to be in contact with the solution. The zinc compartment is then to be filled with a solution of sulphate of zinc, sal-ammoniac, or common salt.

Metropolitan Railway.—On Monday night the Edgware-road Station of the Metropolitan Railway was illuminated for the first time by the electric light. Two lights were fixed in the station, one being placed at each end, about 240 feet apart; and though it could not be said that the illumination was not susceptible of improvement, yet everything was sufficiently clear, and when the electric light was extinguished, and the 25 gas burners generally used were restored, the the difference between the light and the comparative darkness which succeeded was plainly visible. The lighting was under the management of Mr. Ward, of the British Electric Light Company, the sole licensees of the Gramme Electric Lighting Machine, two of which were used. One of these machines was made by the Silvertown Indiarubber Company, and was working at 1,000 revolutions per minute. The other was supplied by Messrs. Sautter, Lemonnier, and Co., and ran 1,100 revolutions. Each machine was calculated to need $2\frac{1}{2}$ horse-power, but the engine used being that which works the lathes, &c., in the workshops, it was not possible to estimate with accuracy the power employed, as a long series of shafts had to be kept revolving. The Serrin lamp was used. It is said that the cost of the lamps amounts to about fourpence per hour, and the gas consumed by the twenty-five jets usually employed to light the station costs about sevenpence per hour. The company are further put to considerable expense for cleaning the large number of lamps in use on the line, besides having to pay for new glasses to replace such as are broken, a cost which amounts on the line to more than £700 annually. The Metropolitan Railway Company is to be congratulated on having thus taken the initiative in its practical introduction in a railway station, and especially as in this case the question of purity of atmosphere is an important one. The electric light does not vitiate the air like its competitor, gas.

Houses Struck by Lightning at Rotherham.—The storm which on Sunday was felt at Wrexham about 3:30 reached Rotherham about 6:30. Rain fell in torrents, and the lightning flashes were unusually vivid. The storm appeared to be at its height shortly before seven o'clock, and about this time damage occurred at three houses in different parts of the town. The most serious injuries were done at the house of Mr. E. H. Slawson, builder, Wellgate. About a quarter to seven o'clock, Mr. W. K. Kenning, Mr. Slawson's son-in-law, was standing at the back door of the house in company with his wife, when the house was struck. As soon as the fire got into the house it burst into two, and by the force of the explosion both Mr. and Mrs. Kenning were thrown to the floor. One portion of the electric fluid took an upward direction, and after knocking the plaster off the ceiling, passed between the laths and into the room above, after burning a small hole in the floor boards. It damaged the chamber ceiling in a similar manner, and then made its exit through the window, breaking five squares of glass in doing so. The other portion of the electric fluid went up the chimney, scattering soot and *débris* in all directions. A child belonging to Mr Kenning was sleeping in a cradle near to the chimney, and it was stunned by some of the material from the chimney falling upon it, combined with the sulphurous fumes which filled the room. It was also thickly covered with soot. Fortunately, however, although it is only four months old, it was not seriously injured. Mr. Slawson, who was in the adjoining room, was very much shaken, as was also Mrs. Innocent, a married daughter, who was in an upstairs room. After the occurrence the premises were visited by hundreds of people. The electric fluid also injured the chimney of the Nag's Head Inn, in the Market-place, and the roof of the brewhouse adjoining. In Greasborough-lane some gas piping which has been recently repaired was destroyed, and a slight fire occurred, but it was fortunately suppressed by means of a few buckets of water.

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LECTURES ON SUBMARINE TELEGRAPHY.*

BY A. JAMIESON, C.E.

The failure of the 1857 expedition has been attributed to the wrong application of the brake power.

Mr. Field started at once for England, and met the directors, who plucked up courage, and agreed to an addition to the capital, in order to procure extra cable for a renewed attempt next year. The Agamemnon and Niagara landed the cable at Keyham Docks, Plymouth, where Mr. Whitehouse, the company's electrician, and staff, were busily employed during part of the winter, experimenting on the velocity of telegraph signals, and perfecting themselves in the *modus operandi* of forwarding and receiving messages through the cable.

A greatly improved system of paying-out machinery was constructed by Messrs. Easton and Amos, of Southwark, under the superintendence of Mr. Penn, Mr. Field, Mr. Everett, the chief engineer of the Niagara, and Mr. Bright. One of the improvements adopted was the substitution of Appold's self-regulating brake, instead of the more clumsy and less easily adjusted apparatus on board of the Niagara. This brake has been universally adopted ever since, and gives great facility for adjusting the required strain to be put upon the cable while being paid out.

Mr. Whitehouse's experiments at Keyham proved the necessity for a more sensitive telegraph instrument than had been hitherto devised; in fact, neither he nor Professor Thomson was able to procure a higher rate of speed than four words per minute through the remaining cable, using abbreviations. This led the latter to invent his wonderful "Mirror Galvanometer," of which we shall have more to say shortly.

The Agamemnon and Niagara were again refitted with all the improved apparatus, and after three unsuccessful attempts to splice and pay out the cable (both ships having met in mid-ocean for the purpose of laying the cable in opposite directions), they were ultimately successful, and the ends were landed at Valentia, and Newfoundland on 6th August, 1858.

The achievement was received both in England and America with the most enthusiastic manifestations of delight.

Considerable difficulty, however, was experienced in despatching messages, principally, no doubt, due to the existence of a fault which had occurred during the laying of the cable, when about 300 miles from Valentia. Messages of congratulation were exchanged between Queen Victoria and the President of the United States. The triumph was of short duration, for, in twenty-six days after completion, it failed to transmit intelligible signals, although, as ascertained by Mr. Varley and others, the continuity had not been broken; but, most probably, the insulation had given way, and the fault opened by an over-powerful application of electricity.

In all about 400 messages passed through the cable, although the speed never exceeded two and a-half words per minute. Yet the results and experience gained were sufficient to warrant a renewal of the enterprise at a future date.

The chief causes which led to the failure may be enumerated as follows:—

1st. Too small a core.
2nd. Defective joints.
3rd. Use of hot tar, exposure to summer heat, and increased temperature, generated by tar coating.
4th. Cable neither kept, nor tested under water until layed.
5th. The numerous times the cable was coiled and uncoiled.
6th. A too-powerful application of electricity in transmission of messages, and in testing.

With regard to the first of these causes, Mr. Gisborne humourously remarked that it was like entering a Shetland pony for the Derby.

Re the fourth cause, it had been advocated by Mr. Webb and Mr. Newall that the cable should be tested under water. In fact, Mr. Webb seems to have tested cables under water during manufacture as early as 1852.

Powerful applications of electricity should be guarded against in the most careful manner, especially when a fault exists. What would we think nowadays of using powerful induction coils to transmit signals? Such a thing would not be admitted for a moment.

This second failure gave a rude shock to Transatlantic telegraphy, not so much from the inability to lay a cable, as from the inadequateness of the electrical arrangements to cope with such a length (or resistance and capacity) of line without using a destructive battery power, and it was not until seven years after that a fresh attempt was made.

In the meantime, however, cables were being constructed, and laid in many different parts of the world, of various lengths, and in various depths, and scientific men were gradually gaining knowledge of the necessary requirements, and making great progress accordingly. It was clearly stated, at the time of the 1858 failure, by the superintendent of the National Observatory, that the real question for projectors of submarine telegraphs was, not how deep, or how boisterous, or how wide, the sea might be, but what were the electrical limits to submarine lines.

Amongst other successfully-laid short cables at that time was one in 1859, between the island of Malta and Alga Grande in Sicily. This cable was manufactured by Glass, Elliot, and Company, for the Mediterranean Extension Company, and worked satisfactorily up to the beginning of last year (1878), when it broke. An attempt was shortly afterwards made to repair it, but it was found that the sheathing had so deteriorated that it would not bear lifting without breaking. The iron wires were originally ungalvanised, and we found them entirely gone in places from corrosion. The gutta percha, however, was apparently in as good condition as when laid down, of which this in my hand is a specimen.

In 1859-60 the Red Sea cables were laid, connecting the different places mentioned in the following table, taken from Report of Joint Committee appointed by Lords of the Committee of Privy Council for Trade and the Atlantic Telegraph Company, to inquire into Construction of Submarine Cables, 1861.

Name of Stations.	Owner of Lines.	Date of Laying.	Manufacturer.	Length Knots.	Description of Cable.
Suez to Kosseir	Red Sea and India Telegraph Company.	May 5, 1859	R. S. Newall and Co.	255	(1). Conductor, 7-wire strand; weight per knot, 180lbs.
Kosseir to Suakin	Ditto	May 17, 1859	Ditto	474	(2.) Insulator gutta-percha, with alternate coatings of Chatterton's compound; weight, 212lbs. per knot.
Suakin to Aden	Ditto	May 28, 1859	Ditto	629	(3). Hemp yarn, 1½ cwt. per knot.
Aden to Hallani	Ditto	Feb. 12, 1860	Ditto	718	(4). Eighteen wires, best charcoal iron, 16 cwt. per knot.
Hallani to Muscat	Ditto	Jan. 30, 1860	Ditto	486	Total weight, 21 cwt. per knot.
Muscat to Kurrachee ...	Ditto	Jan. 17, 1860	Ditto	481	
Total length from Suez to Kurrachee ....knots				3,043	

Mr. Lionel Gisborne was the engineer, and Messrs. Newall and Co. contractors. The English Government gave an unconditional guarantee of 4½ per cent. for fifty years upon the whole

* Delivered at the Malta Station to the Staff of the Eastern Telegraph Company.

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capital required, viz., £800,000, thus relieving shareholders from risk. They appointed an official director, who had a general control over the proceedings of the company, but it is certainly a great pity that the line should have so signally failed in one and all of the sections, long before it ought to have done so. Had it been designed with greater regard to conditions of climate, and the character of the bottom of the sea over which it was laid, there is no doubt it would have lasted longer, and the assistance of Government might have been obtained for other projected lines of equal importance. Mr. Webb, speaking of the proportions of the Red Sea Cable, and of Mr. Gisborne's remarks about the 1858 Atlantic cable, said "the Red Sea cable was like entering a donkey for the Leger."

With the apparatus at present in use, and the weight of conductor and gutta-percha employed in the Red Sea cable, the core was amply large enough for communicating between station and station. In fact, it was larger than the cable laid down in 1870, and which is now worked direct between Suez and Aden, a distance of 1,460 knots, with good results.

The sheathing, however, was by far too light, and in some places laid too taut. The company, in endeavouring to repair the Aden-Suakin section, whose total length as seen by the table was only 629 knots, spent and relaid above 300 miles, rather an expensive repair. Some pieces picked up last year by the Eastern Telegraph Company's steamer Chiltern, while repairing the present 1870 cable, showed that the old Red Sea cable was very much gone by galvanic action, but that the core was perfect as far as it went. On October 28th, 1861, communication was completed between Malta and Alexandria, touching at Tripoli and Benghazi, in Africa. Had the Red Sea cable remained in good order, this last cable would have afforded the missing link of communication between London and Kurrachee, or England and India, for Malta was in communication with London *viâ* Sicily, and a two-wire land line had been erected between Alexandria and Suez, previous to the laying of the Red Sea cable in April, 1859.

The Malta-Alexandria cable had a splendid big core, 400lb per knot of copper conductor, and 400lb gutta percha, and Chatterton insulator, quite a contrast to all former cables in that way.

The core was originally designed for a cable to be laid between Falmouth and Gibraltar direct, afterwards intended to connect Rangoon and Singapore, but finally laid as mentioned.

It is a great pity that, during manufacture and on board ship, the cable was not kept continually under water. Owing to the tanks in the factory and on board the s.s. Queen Victoria not being watertight, the cable was alternately wet and dry. Corrosion set in, and the result was spontaneous generation of heat. This effect had not received much attention before, but in the present instance it was ably investigated by Dr. William Allen Miller, of King's College, London, and Messrs. Siemens and Halske, and gave rise to C. W. Siemens' ingenious resistance thermometer for ascertaining the temperature to which the spontaneous generation of heat had raised the cable.

It most certainly proved the absolute necessity for the cable being always kept cool under water in the factory, and on board ship. This overheating, combined with the fact that the cable was laid too near the coast, and in shallow water for the most part, proved its destruction. It was partly picked up, and partly abandoned, by the end of 1870. Here is a specimen of the Red Sea cable, and here are several specimens of the Malta-Alexandria cable, some of them arranged before the cable was laid, and others from pieces picked up; here is also one of a joint lent to me for exhibition by Mr. Portetti. It seems pretty well made, but I think some of you will be able to make as good a joint after a few more lessons. The Atlantic Telegraph directors by this time were again making great efforts to get money and support to enable them to make another attempt. They asked the Government to give them a guarantee, but the experience which the Government had gained with the Red Sea Company was so unsatisfactory that they refused to assist, neither would they become shareholders in the new project, but they, however, conferred one great benefit by instituting an investigation into the causes of failures, &c., of submarine cables. A joint committee was appointed by the Lords of the Committee of Privy Council for Trade and the Atlantic Telegraph Company, to inquire into the construction of submarine cables. The report of the joint committee was issued in April, 1861, and divided into three general heads, viz.:—

I. A short account of the principal telegraph lines which have been laid.

II. The construction and laying of submarine cables.

III. A summary of principles which they considered should govern these undertakings in future.

It was also accompanied by details of evidence from the most scientific and experienced electricians and engineers of the day, as well as numerous experiments conducted under the instructions of the committee.

The volume containing the report, evidence, and details of the experiments, &c., is most instructive and interesting, and should be carefully studied by every intending telegraph engineer and electrician. It would be a great matter for submarine telegraphy if another similar commission were instituted to inquire into the present condition of the science and art of submarine telegraphy, and thus collect and report upon the advancement since 1861, and point out the most likely path for future success. I believe it would save money in the long run.

The directors of the Atlantic Company failed to raise the proposed capital, and a long pause ensued, and progress in the way of getting up a company ceased until the spring of 1862, when Mr. Cyrus Field, who had never been idle, and who had always believed most implicitly in the project, arrived in England. Still, the formation of a company was slow, for people had not forgotten the previous failures. However, the assistance of five gentlemen to act as a scientific committee was obtained, to consider the best form of cable for submersion between England and America; and out of a large number of samples sent in by different firms for inspection the committee selected the cable No. 46, prepared by Messrs. Glass, Elliot, and Co., as the one best calculated to ensure success. They likewise drew up a series of excellent precautions to be adopted during manufacture. These precautions, to be carried out effectually, entailed closer supervision, and, consequently, greater outlay, and therefore Messrs. Glass, Elliot, and Co. would have required more money to carry out the work than had been contemplated in their tender of Sept., 1863. A powerful corporation was, therefore, brought into existence with Mr. John Pender as chairman. This company was named the Telegraph Construction and Maintenance Company, and it combined the interests of the Gutta Percha Company, and Messrs. Glass, Elliot, and Company, in the form of a Joint Stock enterprise. This company started upon a capital basis, and and was willing to take risks upon the skill and efficiency of their work.

By the assistance of the Telegraph Construction and Maintenance Company, the Atlantic Company was enabled to start afresh. A contract was drawn up, and entered into, whereby the Telegraph Construction and Maintenance Company guaranteed to make and lay a cable with all the improvements, and suggestions pointed out as necessary by the committee just mentioned.

The improvements were as follows:—

1st. The conductor to be nearly three times the weight of the 1857-58 cable, viz., 300 instead of 107lbs. per knot. This was with the view of improving the commercial speed.

2nd. A strict and searching test that all the copper employed in the conductor should have a conductivity of not less than 85 per cent. of pure copper.

3rd. That Chatterton's compound, which is a mixture by weight of one part of Stockholm tar, one of resin, and three of gutta percha, should be applied next to the conductor and between each alternate layer of gutta percha, thus securing mechanical solidity of the entire core, and insuring the closing up of any possible pores or minute flaws that might escape detection in the several layers of gutta percha.

4th. That the insulator should be composed of 400lb. per knot of the combined gutta percha and Chatterton, against 268lb. of gutta percha in the 1857-58 cable. This increased weight of insulator was adopted to insure a decreased inductive capacity and materially assist speed of signalling.

5th. A more rigorous and scientific electrical and practical examination of the several materials composing the cable during manufacture.

6th. A special test of the core at 75° Fahr.

7th. The reduction of all electrical tests (at whatever temperature obtained) to their corresponding values at 75° Fahr., in order to form a ready means of comparison. This was resorted to from the well-known fact that the insulating power of gutta percha decreases, and the resistance of the metallic conductor increases in certain ratios with an increase of temperature.

8th. The core to be subjected and tested under hydraulic pressure, as well as under water, and carefully examined by hand after the application of each successive layer of gutta percha.

9th. The core to be wrapped in yarn tanned in catechu (to prevent decay), instead of tarred yarn. The tarring of the yarn had been found to assist in preventing the detection of faults, and to a certain extent assisted in lowering the insulation, not to mention its detrimental action in the case of jointing.

10th. The sheathing for the deep sea portion to be composed of ten homogeneous iron wires, each wire separately covered with a jacket of tarred Manilla yarn, instead of the eighteen strands of seven wires each in the 1857-58 cable. It was advocated that this homogeneous iron wire would possess the strength of steel, without its bad property of springiness.

11th. The breaking strain was to be much higher, viz., 7 tons

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15 cwt., and the cable to be capable of bearing eleven miles of its own weight perpendicularly suspended in water, whereas the 1857-58 cable could only bear five miles under the same conditions. The new cable was to weigh 35¾ cwt. in air, although only 14 cwt. in water, or but a small fraction more than the former.

12th. The cable was to be kept continually under water in large water-tight tanks, during manufacture and on board ship. This, as we have already remarked, was by no means done in the case of the former Atlantic cable, yet absolutely necessary to insure against deterioration and assist in detecting faults before laying.

(TO BE CONTINUED.)

PLOUGHING BY ELECTRICITY.

(System of Chrétien and Félix.)

BY HYPPOLYTE FONTAINE.*

Some experiments have just been carried out at Sermaize (Département de la Marne) on a new system of tilling by machinery devised by MM. Chrétien and Félix, whose names are already very favourably known in connection with industrial applications.

The problem which these gentlemen have proposed to solve is as follows :—

Cultivation by means of machinery, as at present carried out in England, in the United States, and by some French firms, is based upon the use of travelling steam-engines, brought to the spot where the work is to be done, and working drums upon which is coiled a steel cable, by which ploughs having several shares are drawn through the soil. The apparatus are costly, their conveyance and working are also very expensive; they require special attention in order that they may do the work properly; they are difficult to manage in the fields, especially in wet weather; and, lastly, they require a rather considerable supply of water. The work done by them is better done than it could be by the ordinary means; the deep tilling of the soil which can be effected only by mechanical means multiplies the nutritive surfaces of the arable layer, and produces a mean augmentation of 30 per cent. in the crops,† the bed for the seeds, well pulverised and protected from the inclemency of the weather, ensures a mean crop in unfavourable years, and a maximum of production in those which are favourable.

In spite of all these advantages, tilling by steam has made but very little progress in France, by reason of the subdivision of property, and of the objections enumerated above.

MM. Chrétien and Félix, impressed by this condition of things, and having been for a long time past aware of the remarkable properties of the Gramme machine, have had the idea of employing for cultivation by machinery the hydraulic forces so distributed in France, and as yet so little utilised, as well as the stationary engines established at the various works, farms, and manufactories. These motors are caused to work powerful Gramme machines, producing electricity in considerable quantity; and it is this electricity, conducted to distances of 1,000 and even 2,000 metres, which communicates movement to other Gramme machines, connected directly with the windlasses which move the ploughs.

The Gramme machines can in fact transform motion into electricity, when they are worked by any kind of motor, and also transform electricity into motion when they are placed in connection with any source of electricity. The loss of useful effect produced by this double transformation varies between 30 and 60 per cent. of the initial work, according to the distance of the apparatus and the section of the conducting wires. In practice one may, up to a distance of two kilometres (2,187 yards) from the motor, calculate upon a mean duty of 50 per cent. with conductors 10 square millimetres in section (140·5 *mils* diam.).

Thus on this simple and eminently rational datum as to the easy transport of motive power to a distance the inventors have arranged a set of mechanical apparatus for ploughing, threshing, loading and unloading goods, harrowing, weeding, sowing, and generally for all the operations of high and medium farming as executed in England by means of travelling steam engines.

Two of these sets of machinery have already been established and experimented with at Sermaize, an apparatus for unloading barges charged with beets, and a double windlass for ploughing. The former was working all last winter, and effected a saving of about 40 per cent. on the manual labour. It, moreover, greatly facilitated the unloading of the beets, a fact which is of the first importance in the sugar manufacture, and it allowed of dispensing with the services of special workmen, which cannot always be depended upon.

The ploughing windlasses have been at work only during three weeks, and already they have caused a crowd of visitors to flock to the spot: *savants*, official functionaries, agriculturists, engineers and those attracted by curiosity. During our short stay at Sermaize, we met M. Duphenieux, prefect of La Marne, and Gen. Clinchant, commandant in chief of the 6th Corps d'Armée, who appeared to take a great interest in the experiments.

[An illustrated description of the apparatus is here given.]

The electric cables are suspended upon posts like telegraph wires. The two windlasses are placed 200 metres apart, and, by means of commutators, the electricity is transmitted sometimes to the Gramme machine of one apparatus and at other times to that of the other. As the wire rope unwinds from one drum it is wound upon the other.

As will be understood, the windlasses are automobile, they are made to transport themselves to their destination, and shift their position as the work proceeds.

One of the prime motors at the sugar-works at Sermaize, situated at 300 metres from the field, sets in motion two other Gramme machines which generate the electricity. About 8 horse-power is used for this purpose.

In order not to delay their experiments, MM. Chrétien and Félix have used machines intended for the electric light, and they have had at their disposal for the draught of the plough only 4 horse-power. But they will shortly have much more powerful machines which will allow them to work ploughs with 4 shares, and to penetrate the soil more deeply than they have hitherto done.

For the moment, they use a plough with two shares for light soils, and one with a single share for heavy soils.

The following are a few data relative to the work as effected by the apparatus now being experimented with :—

Velocity of the Gramme machines at the works, 1,600 revolutions per minute.

Velocity of the Gramme machines at the windlasses, 800 revolutions per minute.

Velocity of the friction pullies, 133 turns per minute.

Velocity of the small drum, 14 turns per minute; of the large drum, 27 turns per minute.

Velocity of the motor wheels, 4·6 turns per minute.

Rate of motion of the plough (high velocity) 81 metres; ditto (low velocity) 50 metres per minute.

The furrows are ·275 metre (nearly 11 in.) in width, and have a mean depth of ·2 metre (nearly 8 in). With two shares, about 20 square metres may be ploughed per minute.

The importance and the opportuneness of the labours of MM. Chrétien and Félix on the transport of motive power by electricity will be realised by all. More than ever has our national agriculture need to augment its crops in order to strive against importation from abroad, and to supplement by mechanical appliances the manual labour which is becoming more and more insufficient. The utilisation of numerous falls of water, hitherto left idle for want of economical means of bringing their power into proximity with the highways, constitutes also an immense progress not only for agriculture but for a great number of local industries.

* Translated from the *Revue Industrielle.*

† M. Tisseraud, who directed the exploitation of the domain of Bonkandoura in Algeria, thus resumed the results obtained by ploughing by steam power :—

1. An augmentation of 50 per cent. of the yield in wheat.
2. Crop more certain, better protected from excess of moisture or drought by reason of the great porosity given to the soil.
3. The power of readily ploughing by means of oxen during the greater part of the year following that in which the soil was broken up.
4. A more economical breaking up of the soil than with horses or oxen; but superficial steam ploughing is less economical than that performed with oxen.

INTERNATIONAL TELEGRAPH CONFERENCE.

The delegates sent by their respective Governments to represent them at the International Telegraph Conference began their sittings at No. 1, Grosvenor-place, on Tuesday, June 10. They were received by the Postmaster-General, Lord John Manners, who spoke a few words of welcome, and enlarged upon the importance of their deliberations. General Luders, Director-General of the Russian Telegraph Department, replied; and the deliberations of the Conference then began under the presidency of Mr. Patey, of the Telegraph Department of the Post Office. The proceedings were conducted in French.

The following are the delegates whose names were omitted from the list given last week :—

FRANCE.—M. J. Richard, Engineer-Director of Telegraphs; M. E. Eschbalcher, Chief Officer of Section at the Postal and Telegraph Department.

BRITISH INDIA.—Major H. Mallock.

SERVIA.—M. Radoykorits, Chief of the Postal and Telegraph Department.

ROUMANIA.—M. Robescu, Director-General of Telegraphs.

BRITISH COLONIES.—Victoria, The Right Hon. Hugh C. E. Childers, M.P.; South Australia, Sir W. Milne; New Zealand, Sir Julius Vogel, K.C.M.G.

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A MM. LES DÉLÉGUÉS DE LA CONVENTION TÉLÉGRAPHIQUE INTERNATIONALE.

Salut, et bonne fin à vos travaux! Vos efforts, nous n'en doutons pas, feront avancer le progrès, la civilisation et l'union des nations, aussi bien que la Télégraphie. Nous aimons à croire que vous recevrez ici toute cette hospitalité empressée que l'Angleterre sait accorder aux étrangers distingués, et à laquelle vous avez si bon droit. Et nous espérons que dans le futur vous garderez le souvenir d'une réunion qui aura combiné l'utile avec l'agréable.

FAST SPEED TELEGRAPHY.

Theoretically there is hardly a limit to the speed at which electrical signals may be transmitted through overland lines; and, under favourable conditions, the speed attainable even for the practical service of telegraphy may be very great indeed. This fact, first demonstrated by Bain a quarter of a century ago, was in due time turned to account by the largest of the Telegraph Companies in this country. England has had about thirteen years experience of automatic telegraphy, and may be supposed to know its capabilities. It comes therefore as a surprise to us that, in the very country from whence we borrowed the system a new Company, is being formed on the basis of "Rapid Telegraphy," and plainly on the assumption that the process is altogether novel. We have lately given our readers several extracts from the prospectus and from speeches recommending it; and in a recent Article we commented upon the newness and truthfulness of the statements put forward. A very instructive course of Lectures just delivered by Mr. W. H. Preece enables us now to deal more specifically with the subject. We had, it appears, our automatic transmitter long before we needed it; when we came to need it we used it; and we continue to enlarge the area of its operations whenever and wherever it can be advantageously employed. But the time and place for it are not always existing; in point of fact they have been hitherto comparatively rare; and the introduction of Multiplex telegraphy is rendering them still rarer. The amount of work despatched automatically has been, is now, and probably always will be, enormous; but the number of automatic circuits is comparatively few—a fact very much to the point when we are discussing a proposal to make automatic signalling general and normal. An examination of the conditions favourable and unfavourable to the development of this species of telegraphy will help us to estimate the significance of this seemingly revolutionary project, which has, it is stated, already fascinated our American cousins to the tune of something like three million dollars.

What is the practical working value of a new invention, otherwise unexceptionable, is a question which confiding investors rarely trouble themselves to ask; and it is one indeed which men possessing technical knowledge are too apt to neglect. The promoters of this new enterprise, if we judge them by their public utterances, are not technically ignorant; on some points at least they have realised the possibilities of fast-speed signalling, and have perhaps not inordinately overestimated the powers of their newly devised apparatus. That they appear to be unaware of the existence of similar appliances elsewhere is a little curious; but we are growing accustomed to this kind of national myopy among American inventors. From the practical point of view, indeed, they are just as ill-informed as the ordinary run of people in that and every other country. If we admit that we can signal messages at the rate of 100 words a minute—or say 1,000, for a cypher more or less is immaterial—the popular comment will be, "Why on earth don't you do it?" and if we show that we really do it now and then, "Why," it will be asked, "don't you do it always?" These are natural questions, and they are not answered off-hand. Perhaps the most effectual rejoinder would be, "If you can post your letter to a neighbour round the corner, why don't you always post it?" or, to the merchant, it might be replied, "How much more expeditiously your cotton would be loaded and unloaded if you employed as many porters as there are bales!" Or, again, "How much faster your vessel would travel if you took it to pieces and sent it by rail!" Ridiculous as these quaker-like answers at first sight may seem, they do not in reality exaggerate the inexpediency and the inutility of rapid conveyance where nothing is ultimately gained by it. Everybody will grant this much; but it is only the professional expert who knows how very unimportant in telegraphic transactions is the part usually played by fast signalling. Let us look at this point a little closer.

The pith of the matter lies in this, that for automatic transmission the signals must be prepared beforehand, and translated afterwards. In other words, though the actual telegraphing may be done almost as quickly as you please, the labour of preparation and of transcription is the same as if the signalling were done by hand. The saving, therefore, is only for the wire; and it is obvious that wires requiring these preliminary and subsequent helps are, or ought to be, quite the exception. The preparation occupies rather longer time, in fact, than hand-signalling; and there is no time saved in the final transcription. The process of "punching," and the unavoidable delays at both ends through change of hands, are, consequently, so much lost time. If, in short, the clerk who perforates the message were instead to signal it by hand straightway, it would reach its destination quicker. The fastest despatches in this or any country are those between the Stock Exchanges of our large cities, all of which, as a

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rule, are served by hand telegraphy. In these, as in all other cases where there is a sufficiency of wires and skilful operators, automatic signalling would be a serious hindrance. It comes in as a real boon when messages accumulate faster than keying, on the available wires, can dispose of them. For such contingencies the time occupied in perforating is not wasted, but is saved, for otherwise the messages would be lying idle; and the question for the administrator is: Do the circumstances justify the employment of many additional hands to prepare and to transcribe such messages as exceed the immediate capacity of the wire? Of course the answer will depend upon the particular urgency of the case. On some wires and to certain places automatic signalling may be indispensable; and for any abnormal pressure, for racing messages, for press messages, for long speeches, the fast-speed instrument becomes a necessity if the work is to be cleared off within reasonable time. But, as a general rule, so far from this mode of working being a thing to be desired, the necessity for it is at once a warning that more wires are needed. No one therefore on this side the Atlantic would ever have dreamed of starting a telegraph company on the basis of automatic signalling; for it means either unavoidable delay by reason of insufficient wire accommodation, or unnecessary mechanical delay for the mere sake of augmenting the speed of transmission.

The geographical distances to be traversed in America may render the duplication of wires a more costly consideration than it is in most countries. But there, as elsewhere, the duplex and quadruplex systems will virtually multiply wires to any reasonable extent. There, as elsewhere, the majority of towns can be quite adequately served without the aid of either multiplex or automatic systems. It is true the new company contemplates a great reduction in the tariffs, and expects a commensurate increase of traffic; but we have shown that increased traffic, treated automatically, must result in a slower delivery; and, seeing that most people want their messages delivered quickly, a reduced tariff on such terms cannot be permanently attractive. Increased outlay upon operators, or wires, or both, must speedily follow the temporary success of such a scheme—an outlay all unfavourable to very low tariffs. Finally, we may dismiss, as not worthy of serious consideration, the proposal to distribute perforating apparatus among customers, "who will thus be able to hand in their despatches fully prepared beforehand;" as also the suggestion that "compositors shall set up from the slip without previous translation." "Many compositors," we are told in the prospectus, "prefer to do so!" After this we are surprised that the further statement was not hazarded that many customers, also, would "prefer" to punch their own slip.

CORRESPONDENCE.

DUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to Mr. Muirhead's letter, contained in the last number of your journal dated the 3rd May last.

I do not think it would be right to enter at the present time into the details of the differences which exist between myself and Mr. Muirhead, as these will shortly be submitted to the decision of another tribunal. But the statement which he makes that he has for years past challenged me to take legal steps to decide and enforce my claim, and that I have not thought fit to accept the challenge or take any action in the matter is not in accordance with the facts, and if allowed to pass unnoticed is calculated to prejudice my case. I wish, therefore, to make it known that up to the present time I am advised that there is no sufficient legal evidence that Mr. Muirhead, or any one else, has infringed my patent, such as would enable me to commence proceedings, and that I long ago instructed my legal advisers to commence proceedings, so soon as the necessary evidence could be obtained.—Yours, &c.,

J. B. STEARNS.

London, June 5, 1879.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If Mr. J. Muirhead, jun., had been content with the simple facts, as stated in the lecture, nobody, probably, would have drawn the inferences which he is so suspiciously eager to challenge. Mr. Muirhead has been very energetic—and lucky. But when he puts on the injured air at having his good fortune attributed primarily to "Mr. Stearns' principle," he is plainly appealing to sentiment and not to knowledge. Mr. Muirhead denies that he has used any of Stearns' patents; and states that, on the contrary, he uses an apparatus, "the novelty of which *is not* and *cannot be* disputed." There are different views about what is novel, as there evidently are about what is original. I did not understand Mr. Preece to hold any views whatever on these points, nor do I express any myself. But whether a novelty is disputed, or is not disputed, is a question of fact; and, that the originality of this novelty *has been* and *is* disputed, is a fact known to very many persons, if not to Mr. Muirhead himself. To those persons "the essential difference between mine (Mr. Muirhead's) and Mr. Stearns' system" appears to consist mainly in the former having been influentially backed and practically introduced. From their point of view, indeed, Mr. Stearns has been so unfortunate as to see others reap where he has sown. Mr. Muirhead may regard these opinions as inconvenient or unpatriotic; but he cannot, or should not, deny their existence.—Yours, &c.,

N. N.

May 31, 1879.

CODES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I learn from the *The Electrician* of May 31 that Mr. Whitelaw has published another of those collections of combination code words now identified with his name, will you allow me to make a remark or two upon the subject of code words and coded messages.

I am aware that the matter was well and almost exhaustively discussed in *The Electrician* during the months of June and July last. There was, however, I think, one phase of the question which was passed over or only indirectly noticed. I mean the injury inflicted on non-coding merchants by the great length of words used as code words, and the longer time required for their transmission.

That merchants who, like myself, always telegraph in plain language are entitled to the average rate of despatch cannot be disputed, I think. We pay per letter of the words we send at least double what is paid by the coding merchants. These are not satisfied if they do not send words which are every one up to, or very nearly up to, the maximum ten letters.

Now, take samples of telegrams such as I have sent several lately, "Buy if at," "Buy if under," "Sell if over," "Sell if at," "Sell to arrive," "Don't buy at," "Don't sell at," "Can sell at." It will be seen that seven of the eight telegrams given above contain ten letters or less for three words. Consequently, I pay three times as much per letter as my coding brother merchant who employs long code words, and I repeat that I am entitled to have my messages delivered at least in the average time that *such* messages require for transmission. Yet how is this, if only a few long and difficult-worded messages precede one of mine?

A few months ago I took a telegram (one of the above) to the offices of the Eastern Telegraph Company in Old Broad-street, where, standing at the counter was a clerk who had formerly been in my employ. He had a message of ten or a dozen words, every one of which contained nearly or quite the maximum number of letters, and he jokingly remarked that any one of his words was equal to my whole message in number of letters. I rejoined, "And mean as much, I dare say." "As much!" he replied; "there are but two words in the message that stand for less than twenty-five, and some stand for over one hundred."

Now, had I been but a minute later, the message that preceded mine would have been delayed but very little by following it, whereas my message was no better off than it would have been with two or three, composed of simple words as it was, before it.

I doubt not that merchants who send long telegrams every day look with something like scorn upon those who, like myself, send

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only about a dozen short telegrams per month; but although individually comparatively unimportant, the non-coding merchants are, I think, collectively quite as important to the telegraph companies as their coding brothers; and paying, as I have shown, a higher rate per letter for their messages, they have a right to ask that the telegraph companies shall not tolerate a system that tends to prevent the despatch which we are all so anxious to obtain.—Yours, &c., A NON-CODING MERCHANT.

ILLUMINATION FROM INCANDESCENT METALS.

BY THOMAS T. P. BRUCE WARREN.

At the present time, renewed attention is being directed to incandescence as a source of artificial illumination, it may, therefore, be interesting to collect together the principal facts which are at present available with reference to this portion of Electrical Illumination.

The general idea is that the method of incandescence must be abandoned, partly because it is considered a wasteful process of illuminating, and mainly because we are not in possession of a substance capable of withstanding the high degree of heat which is necessary to render a heated body practically a source of light.

Iridium and an alloy of platinum and iridium are prominently brought forward as suitable for the purpose, in so far as regards the enormous degree of heat necessary to effect their fusion.

Iridium and its alloy with platinum can, of course, be melted, but at the present time, any figure given as their point of fusion can only be regarded as guess work. Messrs. Johnson and Matthey inform me that they are taking steps to ascertain their melting points.

The heat necessary to fuse iridium must be immense, when we bear in mind that Davy, with the celebrated Royal Institution Battery of 2,000 elements, failed to fuse it, although platinum wire melted between its poles, according to his own statement, like wax in the flame of a common candle.

According to Guyton Morveau ("Ann. Chim.," 90,236) the melting point of nickel, platinum, iridium, rhodium, and quartz, is given as being above 175 Wedgwood's Pyrometer (= 6346° Cels).

The following extract from Davy's "Chemical Philosophy," 1812, is interesting in showing what was accomplished in his time.

"The first distinct experiment upon the igniting powers of large plates was performed by MM. Fourcroy, Vauquelin, and Thenard. But the greatest combination ever constructed for exhibiting the effects of extensive surface was made by Mr. Children. It consists of twenty double plates, four feet by two, of which the whole surfaces are exposed, in a wooden trough, in cells covered with cement, to the action of dilute acids. This battery, when in full action, had no more effect on water or on the human body than one containing an equal number of small plates; but when the circuit was made through metallic wires the phenomena were of the most brilliant kind. A platina wire of one-thirtieth of an inch in thickness and eighteen inches long, placed in the circuit between bars of copper, instantly became red hot, then white hot, the brilliancy of the light was soon insupportable to the eye, and in a few seconds the metal fell fused into globules. The other metals were easily fused or dissipated in vapour by this power. Points of charcoal ignited by it produced a light so vivid that even the sunshine, compared with it, appeared feeble.

"Mr. Children has another battery in construction, the plates of which are double the size of that just described, and which are to be arranged in pairs in single troughs, and connected by plates of lead in regular order."

Davy does not say whether this first battery by Mr. Children fused iridium, but he says that "it requires for its fusion a most intense heat." Whether he melted it by means of the celebrated 2,000 plates (Royal Institution Battery) is not stated, but he remarks:—"When any substance was introduced into this arch, it instantly became ignited; platina melted as easily in it as wax in the flame of a common candle; quartz, the sapphire, magnesia, lime, all entered into fusion, fragments of diamond, and points of charcoal and plumbago rapidly disappeared and seemed to evaporate in it, even when the connection was made in a receiver exhausted by the air pump; but there was no evidence of their having previously undergone fusion."

Children's experiments will be found in the "Philsophical Transactions" for 1815, 363, and also in *Schweigger's Journal*, 16, 359. The experiments are made with his larger battery. He says:—"Pure iridium fused into an imperfect globule not quite free from small cavities, and weighing 7·1 grains. The metal is white, very brilliant, and in its present state its specific gravity is 18·68, which must be much too low on account of the porous state of the globule. In the minutes of the experiments in July, 1813, mention is made of the fusion of a small portion of pure iridium into a globule weighing $\frac{62}{100}$ of a grain, which had previously been submitted to the action of a battery of 2,000 plates of 4 inches square without melting."

The following substances were experimented on by Mr. Children with his larger battery, with results as follow:—

"Ruby and sapphire were not fused.
Blue spinel ran into a slag.
Gadolinite fused into a globule.
Magnesia agglutinated.
Zircon, from Norway, was imperfectly fused.
Quartz, silex, and plumbago were not affected.
Oxide of Turgsten fused, and was partially reduced.
,, Uranium fused, but was not reduced.
,, Titanium ,, ,, ,,
,, Cerium ,, ,, ,, and volatilised.
,, Tantalum small portions were fused.
,, Molybdenum readily fused and reduced.
Compound ore of iridium and osmium fused into a globule."

The above is taken from a Paper read by Mr. Children before the Royal Society, June 15, 1815.

Temperatures corresponding to different degrees of incandescence, according to Pouillett:—

Deg.C.			Deg.F.
525	Incipient redness	=	977
700	Dull red	=	1,292
800	Commencing cherry red	=	1,472
900	Brighter cherry red	=	1,652
1,000	Full cherry red	=	1,832
1,100	Dark yellowish red	=	2,012
1,200	Bright ignition	=	2,192
1,300	White heat	=	2,374
1,400	Strong white heat	=	2,552
1,500 to 1,600	Dazzling white	=	2,732 to 2,912

When a body is strongly heated so as to become luminous, it emits together rays of heat and light, the mixture of emitted rays varies with the temperature of the heated body.

Mr. Latimer Clark in his lecture at the Eyre Arms "On the Electric Light" remarked, "that incandescence of metals is a most wasteful process. Professor Tyndall has shown that of those rays of heat and light which emanate from the metal nearly 95 per cent. are the dark heat rays and only 5 per cent. are rays of light. The higher the temperature the greater is the proportion of light rays." This statement must have a very disheartening effect upon anyone who has an idea of turning some attention to this matter as a profitable or useful experiment. It is right therefore to point out that with incandescent metals it is possible to obtain a far higher proportion of the rays of light. Professor Tyndall's 95 per cent. of heat rays and 5 per cent. of light rays apply only to a particular degree of luminosity, and which for the purposes of illumination no one would think of adopting.

ON A NEW METHOD OF INVESTIGATING THE MAGNETIC LINES OF FORCE IN MAGNETS, DEMONSTRATING THE OBLIQUITY OF THE EQUATOR AND AXIS OF BAR MAGNETS.*

BY RICHARD C. SHETTLE, M.D.

It was not until some thousand observations had been made in the manner about to be described that I was rewarded with the discovery of the obliquity of the bar magnetic equator, which is the subject of the present communication.

On a former occasion the Royal Society did me the honour of accepting a similar research of the magnetic condition of arterial and vinous blood. It will be now my object to detail the manner in which I have been led up to the result now obtained.

It appeared to me that the usual method of displaying magnetic currents were of the roughest kind, the curves assumed by steel filings being rough approximations.

Long after I had been occupied with these observations I became aware, through the kindness of Professor Stokes, secretary to the Royal Society, that Sir George Airy, the Astronomer-Royal, had a short Paper in the "Transactions," investigated with a pocket compass furnished with a magnetic inch-needle these lines of force. The method adopted by the writer is essentially different, and greatly excels in delicacy.

* Abstract of a Paper read before the Royal Society.

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In every case the points of parallelism in these equidistant lines, upon being joined by a straight line *p p'*, exhibited *obliquity*.

1*st*.—*Inch magnetised steel needles were suspended and nicely balanced on a single silk fibre* 6 *inches long.*

These needles carried over the magnets assumed rapidly changing positions, and readily demonstrated, as in the Paper alluded to, the varying force and direction as usually portrayed in treatises on magnetism. But these long needles utterly failed in the niceties of research on which I was employed.

2*nd*.—*Needles varying from* $\frac{1}{4}$ *an inch to the* $\frac{1}{16}$ *of an inch were mounted and suspended in a similar manner.*

I found the latter thoroughly competent to trace sudden changes in the magnetic forces. And, for the purpose of recording the curves so traced out, I divided a number of bar magnets carefully into sixteenths of an inch, longitudinally as well as transversely.

The squares so formed gave exact co-ordinates for reference.

Next, the position of the suspended needle $\frac{1}{16}$ of an inch long, or $\frac{1}{8}$ if the curves displayed no sudden curvature, was carefully plotted in each of these squares by means of a hand lens. The accumulation of all these plottings, on careful continuation, gave the curves, as traced from pole to pole.

The equatorial regions adjacent to the centre of the magnets examined were plotted by dotting down the exact position of the suspended minim magnet in its ultimate state of stable equilibrium; these dots were then assiduously joined by a continuous line.

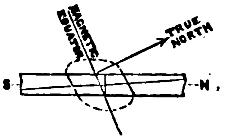
In selecting the initial positions of the extraneous curves, equidistant lines were drawn parallel to the bar, and points were simultaneously elected on two equidistant lines from which to start equatorial curves, such as A and B in the figure.

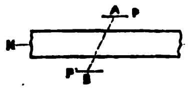
But the principal obliquities are demonstrated by joining the points of contact with the bar of the curves fully traced out from these equidistant points, such as *p p'*.

These curves may be described *as those whose tangents are parallel to the axis of the* bar N S, at points equidistant from it (fig. 3).

According to the curvature, changing slowly or rapidly, a different set of needles is employed, which are preserved, ready for action, in glass tubes.

The work is one requiring great steadiness of manipulation. Some thousands of observations require plotting on a minute scale. Indeed, innumerable curves of great extent and variety have been plotted upon the surface of magnetic bars covered with paper, as seen in the accompanying diagram, No. 1, bar A.





Not only were these curves traced all over the surface of the magnets, but they were also traced a considerable distance away from them laterally.

The nature of these extraneous or lateral curves appears graphically hyperbolic. Any given curve thus formed is the position of the magnet needle traced from point to point, which needle is necessarily under the influence of both the terrestrial and the bar magnetism for the time being, and its direction is *a resultant of the various forces* bringing it to a state of rest at the various points examined.

One of the most striking results of the investigation, when the curves are placed very near the centre of the bar, is the *general obliquity of the magnetic equator of the bar* (fig. 2.)

This obliquity of the magnetic equator of the bar is demonstrated by the *coup d'œil* of the curves traced out magnetically, as shown in the diagram exhibited, and coloured red; this at once exhibits an extraordinary convergence, running obliquely and longitudinally between the poles marked N and S, and these lines embrace the neutral zone, shaded.

The magnetic lines are drawn in red ink; they are enlarged sixteen times the original size,* each square representing the $\frac{1}{16}$ of an inch, and are the outcome of some thousand observations.

The oblique convergency of the magnetic lines towards the north and south poles is strongly pronounced.

The neutral zone above mentioned is indicated by a shading in the diagram, and also by + +

The region of this neutral zone was explored by examining all those points where the suspended magnetic particle of steel exhibited indifference, either of its poles being observed to be equally attracted.

This interesting experiment can be far better appreciated by actual observation than by description; the fact is, that the tiny test-needle attaches itself in this neutral region by either of its poles; each end dips alternately at the same spot, thus giving evidence of the balance, or extinction, of polarity there.

But this novel feature of an oblique zone is more beautifully displayed by examining small curves, traced out in the way indicated, by the smallest test-magnets near the geometrical centre of the bar, for lines equidistant from its axis.

The obliquity (measured as close as possible to the bar by means of curves traced out so as to enter the two sides of the bar) has a very equable value, varying according to the nature of the magnet, as regards the intensity of the magnetism, the quality of the material, and its temper, from 7° to 10°; and this result is confirmed by the investigation of the internal curves of many thousand observations on magnets from $7\frac{1}{2}$ to 18 inches long. Indeed, it was the invariable inclination of the surface lines which suggested the equatorial obliquity.

* The principle of squares was adopted in the enlargement, a lens being employed on the original chart.

A FEW MORE REMARKS ON MR. L. VIANISI'S DUPLEX SYSTEM.

By Dr. A. Tobler, of the Federal Polys. School, Zurich.

A short time ago I had a correspondence on Mr. Vianisi's duplex system with Mr. Weidenbach, telegraph engineer to the Cologne-Minden Railway (author of the "Compendium der Telegraphie," as quoted in my first Paper), and it might be of some interest to the readers of my first Paper (*Electrician*, Vol. II., No. 23) to receive a more detailed account on a few details of the system.

It has been supposed (V., first Paper) that the resistance in the rheostat should be made equal to line + receiver. By means of formula (IV.), however, a better value of Rh may be found, *i.e.*, the difference of magnetic moments in the cases II. and III. may be still more reduced by assuming the strength of current in the receiver of the sending stations to be 0.

Let us put in formula IV.

$$J_3 = \frac{E_1 W_2 - E_2 W_1}{W_1 (W_2 + W_3) + W_2 W_3},$$

which represents the current acting on the receiver of the sending station—

$$W_1 = V + L + \frac{Rh\, W_3}{Rh + W_3},$$
$$W_2 = V + Rh$$

(L = resistance of line, W_3 = resistance of receiver, V = resistance of battery, Rh = resistance in the rheostat).

We then get—

$$J_3 = \frac{E_1 (V + Rh) - E_2 \left(L + V + \frac{Rh\, W_3}{Rh + W_3}\right)}{\left(L + V + \frac{Rh\, W_3}{Rh + W_3}\right)(V + W_3 + Rh) + (V + Rh)\, W_3} \qquad \text{(IVa)}$$

If, now, the condition to be fulfilled is that, in case the second, the current in the receiver of the sending station be 0 (E_1 is supposed, *à priori*, to be = E_2), then there must be, according to (IV*a*)—

$$L + V + \frac{Rh\, W_3}{Rh + W_3} = V + Rh.$$

From this latter equation we deduce:

$$Rh = \frac{L}{2} \pm \sqrt{\left(\frac{L}{2}\right)^2 + L\, W_3}. \quad . \quad . \quad \text{(I.)}$$

Of course T_3 will always keep a certain very small value.

By inserting this new value for Rh in our numerical example (*vide* first Paper), we get—

(L = 1200 S.U., W_3 = 400 S.U., $E_1 = E_2 = 18$, V = 108 S.U.)

$$Rh = \frac{1200}{2} \pm \sqrt{\left(\frac{1200}{2}\right)^2 + 1200 \cdot 400} = 1516\ \text{S.U., approachingly.}$$

By inserting the corresponding values in formula (IV*a*), we then get—

$$T_3 = -0{,}0000018, \quad T_1 = 0{,}01108144, \quad T_2 = 0{,}0110832.$$

The current acting on the receiver of the receiving station is—

$$J_1 \frac{Rh}{Rh + W_3} = 0{,}0087,$$

and the magnetic moment

$$0{,}0087 \sqrt{400} = 0{,}1740.$$

In case the third we have for each station—

$$J = \frac{18}{1516 + 108 + 400} = 0{,}0088, \quad M = 0{,}1760.$$

The difference of magnetic moments in cases two and three is

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D = 0,002, *i.e.*, the same result as was obtained (*vide* first Paper) by the insertion of an artificial resistance between terminal 1 of the key and the line.

In Mr. Vianisi's duplex system, like in all others (except Mr. Schwendler's double-balance method), balancing the outgoing current at one station disturbs invariably the balance at the other station; therefore, if balance in any one station has been once disturbed, it can be regained only by successive adjustments in both stations. On the rather short Zurich-Schaffhausen and Lausanne-Geneva duplex circuits it is the usual practice to establish balance by a common detector inserted between receiver and earth. For circuits of greater length a more refined arrangement would be necessary. Thus, on the Paris-Marseilles and Paris-Lyons circuits, which are worked by Mr. Aïlhaud's Hughes' duplex, a Thomson's reflecting galvanometer is employed for controlling the balance.

The Vianisi duplex has still a slight fault, which has been mentioned already in the first Paper, *i.e.*, the battery is momentarily short-circuited during the play of the key. The battery, which consists of Calland elements, is not much affected by it (except the useless waste of material); but it might be apprehended that an effect might be produced on both receivers. In this case the current acting on each receiver will be—

$$J_1 = \frac{n\,E\,\dfrac{Rh}{Rh + W_3}}{V + L + 2\,\dfrac{Rh\,W_3}{Rh + W_3}}, \quad . \quad . \quad . \quad (II.)$$

i. e. (by insertion of the numerical values) = 0,0073, or 84 per cent. of the current which produces the signals.

In practice, however, this is of no consequence, the duration of the short circuit being too small. I have tried in vain at the Zurich station to produce an effect on the home receiver by depressing the key very slowly. Till now the key designed by Mr. Vianisi has worked to the entire satisfaction of the officials.

SUBMARINE CABLES AND INTERNATIONAL LAW.

Now that a Telegraph International Conference is holding its sittings in England it is to be hoped that the question of the law, or rather want of international law, as regards submarine cables, and the damage to them during peace and war, may be in some form broached before the conference closes.

At present there can be no doubt that the question of liability as regards careless injury of a cable is in a very unsatisfactory state. Cables are injured or broken, and there are no means of bringing the offenders to a fair trial as to the degree of culpability and liability.

With the amount of property invested in cables, this becomes yearly a more and more serious question; and although it would be perhaps beyond the province of the delegates to agree to any general law, still, if the discussion of the matter was at least commenced, there would be a chance of some skeleton agreement being come to which could form the basis of more mature consideration by the higher authorities in each country.

As regards the distance of three miles from each coast there appears to be some sort of right admitted of jurisdiction; but even this, since the Franconia collision case, seems to be in a somewhat doubtful state. But beyond this there appears to be absolutely no law. Yet cables pass through grounds where ships anchor, and fish, and dredge for coral, miles beyond the three miles. Here, then, is a point where international law should define under what circumstances a ship shall be liable for damage to a cable. Ships should also be made, under heavy penalty, to give immediate notice of having had hold of a cable, as this must be important information as regards repair, for, although a single fault in an otherwise perfect cable may be easily localised, yet in a cable with several weak places, the position of a final fault is not so easily ascertained.

Again, cables lie near one another, and in dredging for one cable another may be damaged. This is a point that could be discussed. Cables also cross one another, and in picking up the lower cable the upper one will certainly be broken, unless the under one breaks, or is cut at the place of crossing, and grappled on the other side of the crossing.

Here, then, is a question to be decided; all points of crossing should be carefully defined, and no ship should go to sea to pick up an under cable without having obtained on the best authority the exact place of the crossing. It is also a question for a conference to decide whether it should not be agreed that the under cable shall be always cut at a reasonable and safe distance from the other cable, so as to avoid the chance of sawing the latter in two, and then grappling for the under cable beyond the crossing, even though a few miles of cable have thus to be sacrificed. The question of which owners should bear the expense of abandoned cable should also be decided.

The question of the cables during time of war might also be considered. It would, perhaps, be too much to expect that any agreement could be come to as to leaving cables untouched during a war, but some understanding might be come to so as to cause as little expense to the owners as possible in the repair of such cables after the completion of the war. At present, if France was at war with England, and cut the Atlantic cable, there would be no law to prevent a French privateer picking up a few hundreds of miles, or indeed the whole cable. Already a cable on the coast of South America has been cut for war purposes, and forms an example that should be watched with interest. Indeed, there seems little in the way of law to prevent a ship helping herself even in time of peace to cable far from land.

We have only shadowed forth in the briefest way possible the state of the case, but it is evident that some sort of action in the matter might be taken during the conference, so as to make some advance in a subject which we believe Mr. Cyrus Field at one time took up, and which must some day, if not dealt with internationally, cause direct pecuniary loss to private individuals as well as indirect loss to whole communities in the form of unnecessary interruption to telegraphic communication.

THE INTERNATIONAL TELEGRAPHIC CONFERENCE OF 1875.

The following are the signatures attached to the Regulations for International Service annexed to the Convention drawn up at St. Petersburg:—

GERMANY.—R. Scheffler, Counsellor at the General Directory of Telegraphs for the German Empire.

AUSTRIA. — Brunner-de-Wattenwyl, Aulic Counsellor at Vienna.

HUNGARY.—L. Koller de Gronzow, Counsellor at the Ministry of Commerce of Hungary.

BELGIUM.—Vinchent, Inspector-General at the Department of Public Works for Belgium.

DENMARK.—Faber, Counsellor of State, Director of Danish Telegraphs.

EGYPT.—Betts Bey, Inspector-General of Egyptian Railways; Soliman Effendi, Telegraph Engineer.

SPAIN.—L. M. de Tornos, Sectional Director of the Spanish Telegraph Corps.

FRANCE.—Ailhaud, Inspector-General of Telegraph Lines in France.

GREAT BRITAIN.—Alan E. Chambre and H. C. Fischer, delegates for Great Britain.

INDIA.—Robinson, Colonel R.E., Director-General of Indian Telegraphs; M. Bateman Champain, Major R.E., Director-in-Chief of the Department of Indo-European Telegraphs.

GREECE.—S. Marcoran, *Chargé d'Affaires* for Greece.

ITALY.—E. d'Amico, Director-General of Italian Telegraphs.

NORWAY.—C. Nielsen, Director-in-Chief of Norwegian Telegraphs.

HOLLAND.—Chief Officer of the Division of Telegraphs at the Finance Ministry of Holland.

PERSIA.—D. Lueders, delegate for Persia.

PORTUGAL.—Valentino do Rego, Director of Telegraphs and Lighthouses in Portugal.

RUSSIA.—De Lueders, Director-General of Russian Telegraphs.

SWEDEN.—D. Norlander, Director-General for Sweden.

SWITZERLAND.—Colonel Hammer, Minister for Sweden; A. Frey, Director of Swiss Telegraphs.

TURKEY.—Dimitraki Effendi. Superior functionary of the Administration-general of Telegraphic and Postal Service for the Ottoman Empire.

The following sections of the Convention appear to be of special interest in relation to the proceedings of the Conference to be held in London:—

III.

The Morse and Hughes apparatus will continue to be adopted for the service on international lines until a new understanding be arrived at in regard to the introduction of other apparatus.

XV.

The minimum taxation is applicable to telegrams not exceeding twenty words in length. The charge applicable to the telegram of twenty words is increased by half for each indivisible series of ten words above the twenty.

For the extra European correspondence the charge is made per word for the whole distance without any condition of minimum for the number of words, or with a minimum of ten words. The

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system of taxation that an extra-European Office may declare to have adopted shall, moreover, be applied indifferently to all the communications exchanged with extra-European Offices.

XXI.

1. The maximum length of a word is fixed at fifteen characters according to the Morse alphabet; any excess above this number, similarly up to fifteen characters, is counted as a word.

2. For extra-European correspondence, this maximum is fixed at ten characters.

XLIII.

1. Every sender has the right of transmitting by telegraph a simple notice which is not subjected to the formalities of ordinary telegrams.

2. The telegraphic notice is admitted only between European countries. It is limited to a maximum of ten words, and cannot be drawn up either in language expressed by figures, nor in language having a special conventional signification; numbers are admitted only when written in full.

XLIV.

1. The sender of a private telegram may obtain priority of transmission by writing the word urgent before the address and by paying three times the charge for an ordinary telegram of the same length and over the same distance.

LI.

1. In the case of the Administrations which accept this mode of correspondence, every sender has the power of making his telegram special.

2. When a telegram is made special, the Administration which has received it undertakes to pay to the sender, in all those cases which give the right to reimbursement of the charge for repeated messages, a fixed sum of fifty francs, besides the amount of the charge made. When, however, the irregularity is due to a case of *force majeure*, then the sender is entitled only to the restitution of the charge made.

5. The charge for the special telegram is three times that for an ordinary telegram.

LXXVIII.

1. The joint expenses of the international office of the Telegraphic Administrations should not exceed, *per annum*, the sum of 60,000fr., exclusive of the special expenses which may arise from the meeting of an international Conference. This sum may at a future period be augmented by consent of all the contracting parties.

LITERATURE.

The Electric Light in its Practical Application. By Paget Higgs, LL.D., D.Sc. E. and F. N. Spon.

Dr. Higgs has produced an excellent work of its kind. We say of its kind because we must always take into consideration the aims and object of the author, as well as our own idea of what a work ought to be. In the preface the author announces his aim:—"To give the reader an account of what has been effected in the numerous endeavours to obtain a practicable system of electric lighting. But the details have been confined to those necessary to form a judgment of the advantages of each system. Abstruse discussion has been avoided, and questions have not been raised to which answer could not be found in previous practice." Dr. Higgs has been wise to pursue this course, inasmuch as his work will commend itself to a far wider audience than if he had restricted himself to purely theoretic discussions, and, furthermore, theory is not yet quite certain of the ground upon which it stands. True it is that a good deal can be stated definitely, but there are many points connected with electric lighting on which there is not the necessary data from whence general deductions can be drawn.

Dr. Higgs commences by pointing out the methods by which the electric light is obtained, viz., the voltaic arc, incandescence, and by means of Geissler tubes. Then he proceeds to discuss the various lamps that have been brought prominently before the public, from the time of T. Wright, in 1845, to the present, when we have before us such lamps as those of Serrin, Carré, Lontin, Reynier, Werdermann, Rapieff, Brune, Krupp, &c., and one not previously described, of the author's invention. The description of this lamp is given below, and, by the courtesy of Messrs. Spon, we give also the illustration from page 43 of the work:—

"With considerable experience in the practical manipulation of most of the existing systems for electric lighting, the author has found that some systems presented considerable, and that others of more delicacy of adjustment necessary to practical employment gave insuperable, difficulties. These difficulties arise chiefly from three causes: that the carbons are not homogeneous, the current inconstant from variations in the resistance of the circuit, and generally from the want of promptness in the mechanism of the lamp to respond to the variations so caused. Most of these electrical apparatus have been devised either with too broad or imperfect views, or with only special application. In the case of carbon-holders carrying seven or eight inches of carbon to be consumed, the resistance of this amount of carbon, if the material is not of the highest quality, is likely to exceed that of the arc and lamp itself *ab initio;* and this resistance, constantly varying, has to be compensated for by the mechanism of the lamp. This imperfection has been avoided by Rapieff, Werdermann, and Lontin. Some inventors have recognised it, and have proposed, as a remedy, to electrotype the carbon rods with a conducting metal; but the practical electro-metallurgist is cognizant of the difficulty of obtaining regularity in such deposits of metal, and the expense of the coating is, besides, to be taken into account. In each case the long length of carbon becomes heated, and with coppered carbons the mass of metal is insufficient to carry away the heat generated by the passage of the current.

"The first aim of the electrician who has to maintain an efficient and steady light is undoubtedly to obtain as constant a current as is possible with either battery or electric machine. Battery currents vary, as a rule, very gradually; currents produced by mechanical motion are subject to the irregularities of that motion. The slip of belting, the beats due to want of balance in the fly-wheel, are represented in the electric current with too much fidelity for the comfort of the electric-light engineer. But with care these causes of irregularity can be avoided, and the needle of even a delicate galvanometer, interposed in the circuit of a well-set machine, driven by a steady motor, will remain fixed at a degree of deflection representing the current strength.

"But this steadiness vanishes immediately the electric lamp is introduced into the circuit, so far as the lamp is concerned. This occurs partly because the lamp is, as regards the light it emits, a much more delicate current measurer than the galvanometer. The light power from the carbons of an electric lamp depends not directly upon the current strength, but increases or decreases far more than proportionally. The heat produced by the current varies as the square of the current strength, and the light varies in some such ratio as regards the heat. Thus, a variation in current intensity, measured by the number 2, may be considered in illustration as causing a variation of 16 in the light intensity. It is, therefore, needful to avoid causes of variation in the lamp, for these, it is evident, will have similar effect upon the light intensity to those arising with the machine. Indeed, variations introduced by the lamp cause variations to occur from the machine, unless the latter be extremely well governed. A decrease of resistance in the circuit causes more work to be thrown upon the motor, and *vice versâ.* If the motor, in consequence, momentarily slackens or increases speed, there must elapse several moments before the same conditions as existed before the disturbance are again established, and the largest of these variations are certainly visible as variations in the light. That most of these variations are due to reaction from variations in the lamp itself, is proved by the superior steadiness of the light produced on the principle of incandescence alone. This fact has caused many inventors to overlook the cost of the light produced merely by incandescence, and to avoid in their lamps the use of the voltaic arc, with what appears to be its necessarily attendant irregularity.

"The lamp illustrated overleaf is an attempt to avoid as much as possible causes of irregularity, and at the same time to produce a light with small expenditure of power. It utilises the principles of incandescence, of the arc, and of the extra spark. It consists of an electro-magnet, in face of which is an armature mounted on a spring. The armature carries a block of carbon, iron, or compounded material as a negative electrode, which is not consumed, or is consumed with extreme slowness. The positive electrode is a carbon rod, carried in a tube and falling with a certain friction imposed by a weighted lever, which admits carbon rods of several sizes to be introduced, as may be best suited to the strength of the current. The falling of the carbon can be aided by a weight or spring. The distance of the bottom of the tube from the negative electrode can be adjusted, and limits the length of carbon rod rendered incandescent by the current. When the current passes, through the positive carbon coming into contact with the negative electrode, the armature is attracted, and the voltaic arc and extra spark appear; the current, weakened by this action, fails to keep the armature attracted, and in this manner a constant vibration of the negative electrode is established. This vibration is imperceptible to the eye. Its advantage, beyond that of producing the extra spark, which spark itself appears to afford aid in maintaining the voltaic arc, is that the armature has no dead point, and floats as it were above the electro-magnet, in a condition to respond promptly to mag-

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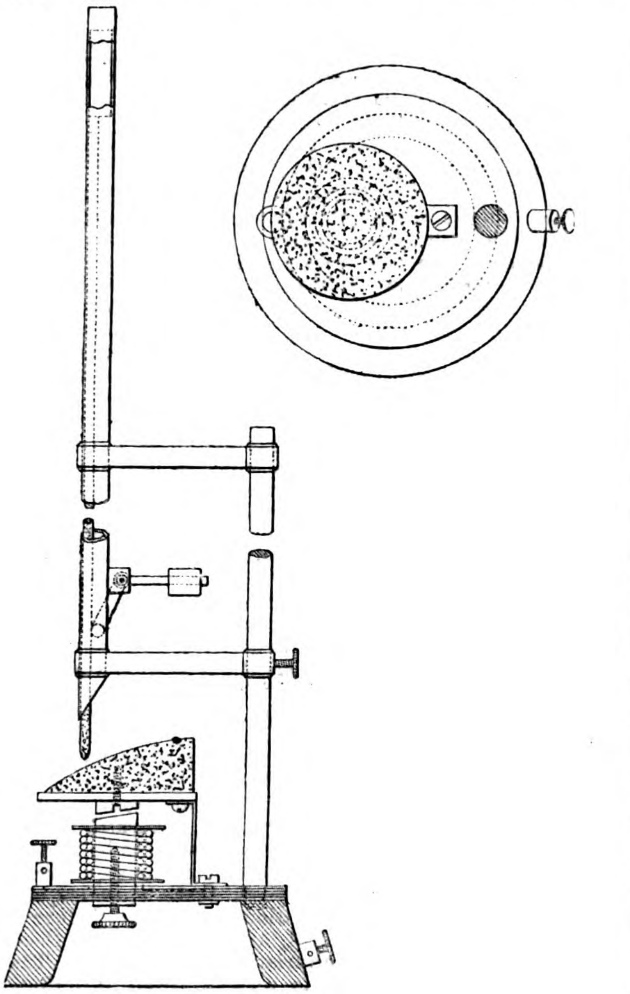
netic effects caused by larger increments or decrements of current strength.

"It is preferable to place an insulated spring between the end of the friction-lever and the armature, instead of the weight on the end of the lever; the carbon rod is then allowed to fall freely when required, and as released by the rising of the armature.

"With only four ordinary Bunsen elements, sufficient light has been obtained to illuminate a shop 60 feet by 40 feet; and upon the single circuit of a dynamo-electric machine absorbing $2\frac{1}{2}$ horse-power, four lights of about 400 candle-power each have been obtained, with sufficient steadiness to read by with comfort."



A chapter is devoted to electric "candles," another to lamps of incandescence, and then we have a discussion of the theory and a description of the most important magneto and dynamo-electric machines. Most of these have at various times been described in our columns, but here in a compact space one can compare the various peculiarities of the machines, and soon obtain an idea of the principles upon which each is based. The report of the Franklin Institute is given complete, as it deserves, for it is one of the most important reports ever written. We cannot help feeling honoured by the way in which the author has used our columns, in giving the formulæ, &c., contributed by Mr. Desmond FitzGerald, to which are added a *précis* of Mr. Schwendler's report, and the Paper of W. H. Preece, from the *Philosophical Magazine*. The various regulations proposed for regulating the currents are noticed, as is the commercial aspect of the question, the work concluding with chapters on the Application of the Electric Light.

We have thus briefly glanced at the contents of the work, without criticism. As regards the latter, our opinion, be it worth what it may, is altogether favourable, and we think Dr. Higgs has provided a book calculated to give the public a fair idea of what has been done regarding the electric light. The illustrations throughout are very good, and there seem to be but few errors in the printing. At least we have noticed but one, and that in a formula on p. 159.

ERRATUM.—VARNA AND BALACLAVA CABLE.—The length of this cable was 310 knots, and not 150 knots, as printed by error in the report of Mr. Jamieson's lecture on page 27.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices June 11.		Business Done Week Ending June 11. Highest.	Lowest.
Anglo-American	55¾,	6¼	57	56¼
Do. "B"	85¼,	¾	86¼	85
Do. "A"	27½,	28	29⅛	27⅞
Brazilian	7,	⅛	7⅛	7
Cuba	8¼,	¾	8¾	8 9-16
Do. Ten per Cent. Preference	16,	17	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	10½,	11	11⅛	11
Direct United States	10½,	¾	11¼	10¾
Eastern	7¾,	⅞	7⅞	7⅝
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	101,	103	102	102
Do. Six per Cent. Preference	11¾,	12	12	11¾
Eastern Extension	7¾,	⅞	7½	7 11-16
Do. Six per Cent. Debenture	107,	110	109	109
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4⅞,	5	5 1-16	4⅞
Do. Six per Cent. Preference	10 15-16,	11 1-16	11⅛	10⅞
Great Northern	8½,	¾	8¾	8 9-16
Indo-European	20,	21	—	—
Mediterranean Extension	2½,	3	3	3
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9,	10	—	—
Submarine	225,	235	228	227
West India and Panama	1⅝,	⅞	1 9-16	1½
Do. Six per Cent. Preference	7⅞,	8⅛	8⅛	8
Western and Brazilian	3⅝,	⅞	3¾	3¾
West. Union Seven per Ct. 1st Mt	112,	116	—	—
Do. Six per Cent. Sterling	103,	105	—	—

TRAFFIC RECEIPTS FOR MAY, 1879.

Companies.	May 1879.	May 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	—	—	—	—
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	15,970	—	—	—
Eastern Extension Telegraph Company	25,845	23,844	2,001	—
Eastern Telegraph Company	38,371	33,650	4,721	—
Great Northern Telegraph Company	18,917	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

VOLUNTEER CAMPING AND THE ELECTRIC LIGHT.—The British Electric Light Company have arranged to light up the camp of the 3rd Northamptonshire Volunteers at the end of the present month.

THE SYDNEY EXHIBITION.—The works are being actively continued. At night the electric light is used. It is stated that the opening of the Exhibition is to be postponed from September 1 to October 1.

ELECTRIC LIGHTING IN ST. PETERSBURG.—The Municipal Council, under the presidency of M. le Baron Koff, in its sitting of the 30th of May, decided on erecting electric lights by the Jablochkoff process on several points of the city, particularly on the great bridge of Citernaya.

THE "RAPID" TELEGRAPH COMPANY.—Although this company has not recently indulged much in publicity, it appears that it has been quietly making arrangements for getting its lines built. Poles have been bought, and the erection of them will commence at once. The first line will be from New York to Boston, and afterwards to Washington and Chicago, and will consist of three wires, two for "machine" telegraphing, and one for the ordinary Morse. It is thought that the company will be ready for business by the early fall. The lines it proposes to build will be unusually substantial.

ELECTRIC LIGHT IN HYDRAULIC MINING.—The first electric light ever introduced in a mining claim was placed on the Deer Creek placer claim of the Excelsior Water Company at Smartsville, on the 10th of last April. A 12,000-candle power Brush machine was put in operation, and three lights of 3,000-candle power each were placed in prominent positions upon the claim. Although the night was very dark, the lights shed a brilliant light around, and enabled the miners to work as readily as during the day. Until this experiment the mines had to shut down during the night, but now the company expects to work both night and day. Nevada and Yuba counties have many hydraulic mining companies, and several of them have announced their desire to use the new light if the Excelsior Company is thoroughly satisfied with their machine. As Mr. Law has received several telegrams from the company, which state that it is working well, there can be no doubt that it will be adopted. The three lights cost the company about 10 cents per hour, and with interest, wear and tear, &c., included, the claim is lighted for 16 cents per hour. The company's daily clean-up is from 500 dollars to 1,000 dollars, and, by running nights also, the yield of the mine can be doubled.—*Nevada Transcript.*

A PACIFIC CABLE.—That eventually a cable will be laid from the Pacific coast to the Sandwich Islands, Japan, and China there can be no doubt. When this line is established the telegraphic circuit of the world will be complete. Mr. Cyrus W. Field holds an exclusive concession from the Government of the Sandwich Islands for such a cable, as was announced at the recent celebration of the twenty-fifth anniversary of the organisation of the company which resulted in laying the Atlantic cable. Concessions will also be obtained from Japan, and probably from China. We understand that the organisation of a company to carry out this project is proposed, and that Mr. Field has agreed to contribute 100,000 dollars in cash as a subscription to its capital stock. It is expected that capitalists upon the Pacific coast, who will naturally feel a pride in the establishment of such a line, will also contribute liberally to give the project a start and carry it through. The business interests of the coast would be greatly facilitated by such a connection. Mr. Field sailed for Liverpool on the 21st ult. in the Cunard steamship Bothnia, and during his sojourn in England will make such investigations in regard to the manufacture and laying of a Pacific cable as will enable him and his associates to act understandingly in furthering the proposed enterprise. No steps will be taken towards organising a company until after the return of Mr. Field. It is to be hoped that sufficient encouragement will be extended to insure the construction of the line at no distant period.—*Journal of the Telegraph.*

THE TELEGRAPH IN NEW YORK.—The following table will give some detailed idea of the extent of telegraphic wire over the city, although in a few instances the names of companies, or the length of wire employed, has not been obtained:—

	Miles of wire.	lb. weight per mile.	Battery Jars.
Western Union	1,142	350	9,500
N. Y. Private Line and Telephone Department	1,200	250	6,500
Fire Telegraph	750	300	1,200
Private Lines	400	200	1,500
Bell Telephone	400	163	1,500
Gold and Stock	155	300	8,000
Atlantic and Pacific	290	335	1,150
American District	300	163	2,500
Law Telegraph	225	200	250
Holmes' Burglar	165	150	1,500
Automatic Signal	—	—	—
Police	100	300	185
Commissioners of Charities and Correction	20	300	30
Armouries	22	300	70
Hospital Service	7	300	21

It will be seen by the above that the armouries of the militia and the hospitals are connected by telegraph with the Police Head-quarters, and even the institutions under the Commissioners of Charities and Correction; consequently, the telegraph system of New York City is nearly as perfect as it can be, although the future may even develop greater facilities.

THE ELECTRIC LIGHT IN PICTURE GALLERIES.—Mr. John Leighton, writing to a contemporary, judiciously criticises the effect of the electric light, as applied on a large scale to the illumination of the Paris *Salon* on the 7th inst., upon the pictures and statuary there exhibited. According to this authority, the illuminating power was too diffused and too near the pictures, each lamp having a reflector behind a crystal sphere of glass, which, unfortunately, cast a mottled light upon the works of art and the walls, and a glare that picks out all the bits of burnished gold. The light in the saloons was much too intense; there being eight globes in the larger rooms and six in the smaller; each globe containing eight candles. The reflection from the surface of the works was annoying; the manipulation of the painter being apparent, as also the texture of the canvas, and even the strokes of the brush and the underwork. The blue and white tints told out in an extraordinary way, whilst the soft yellows and greens suffered terribly. Distemper and water-colour, and the monochromes, stood the light best.

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"The great hall," says Mr. Leighton, "should have been lighted from the roof; then the effect would have been perfect, and some of the shadows so essential to sculpture maintained." "The electric light," he adds, "has many advantages, and doubtless will hereafter lend itself more kindly to colour even than now; at present it is a giant not easily controlled." We understand that some of the suggestions made by Mr. Leighton are at the present moment being acted upon.

Electric Stone-Dresser.—We recently noticed that the complaints of millers had led to the use of electricity in getting rid of wire that was detrimental to grinding. Now we have to record that Mr. Cranston has just introduced an electric stone dresser, which has been successfully applied to the dressing of millstones, and is likely to prove equally useful wherever delicate and accurate dressing is necessary. The chisel employed is fastened to a spring arm, which protrudes from a case containing magnets and armatures. This spring arm, when the magnets are connected with the dynamo-electric machine, moves up and down with extreme rapidity, the chisel striking a blow at each descent. The inventor says it can strike from 1,000 to 2,000 blows per minute. Wires being used in place of steam pipes enables the apparatus to be moved readily to any angle, or worked at any reasonable distance without much loss of power; while not the least meritorious portion of the whole invention is the horizontal frame or base to which the electric apparatus is fixed. This frame is portable, and by the use of screws can be so adjusted as to cause the chisel to strike any portion of a circle with either a swift or slow motion, the number and intensity of the blows being regulated according to the softness or hardness of the stone. By the use of this machine, Mr. Cranston claims that he can cover a millstone in a very short space of time with the necessary groove and furrows, having the straightness, regularity, and parallelism so much desired in good millstone dressing. The apparatus can be worked either automatically or by hand, and although with the present cost of electricity the principle is not adapted to rock-drills, it is considered that at a future time an electric rock-drill similarly arranged might become practicable.

The Society of Telegraph Engineers.—On Wednesday evening, June 18th, a *conversazione* was given by the Society of Telegraph Engineers upon the occasion of the presence in London of the delegates to the International Telegraph Conference. The *soirée* was held in the western galleries of the South Kensington Museum, which were kindly lent by the Lords of the Committee of Council on Education. The occasion brought together a large number of telegraph engineers, electricians, and other gentlemen interested in telegraphic and electrical science, who were thus afforded the opportunity of meeting the delegates. The visitors were received by Lieutenant-Colonel J. U. Bateman-Champain, R.E., president of the Society of Telegraph Engineers, who was supported by the Council of the society. A very fine collection of telegraphic apparatus and instruments of every description was arranged in the galleries and served to render the *soirée* a most interesting one. The following among others exhibited a fine collection of apparatus:—Latimer Clark, Past President S.T.E.; Latimer Clark, Muirhead, and Co.; E. A. Cowper, M.S.T.E.; Eastern Telegraph Company; Elliott Brothers; India Rubber, Gutta Percha, and Telegraph Works Company (Limited); Johnson and Phillips; Krohne and Sesemann; Phillips Brothers; Her Majesty's Postmaster-General; Siemens Brothers; Spagnoletti, C.E., M.S.T.E.; Telegraph Construction and Maintenance Company; Theiler and Son; Sir William Thomson, F.R.S., LL.D., M.S.T.E. Outside the galleries, and at the top of the building, were four Siemens' electric lamps, which received their current from a machine placed in the Albert Hall. They were fitted with reflectors, and shed a brilliant light over the terraces and gardens beneath. This was the only attempt at electric-lighting, the galleries themselves being illuminated by the ordinary gas jets. During the evening the band of the Royal Artillery performed an excellent selection of music, and altogether the gathering was of a very pleasant and interesting character, and the *conversazione* was in all respects a thorough success.

Testing Iron and Steel by Electro-Magnetism.—Two interesting practical applications of electro-magnetism have recently appeared. In one it is applied to discovering flaws in iron or steel; in the other to measuring the hardness of steel. The theory of the former process (proposed by Mr. Herring, an American mining engineer) is this—When an iron or steel bar is passed through a coil which is traversed by an electric current, the bar becomes a magnet. If the metal be homogeneous, the polarity of the bar may be inferred from known laws of electro-magnetism. If, however, there be a want of continuity of fibre at some point, *i.e.*, a flaw, new poles are formed there, which a properly mounted needle will readily detect, also giving a measure of the extent of the imperfection causing these false poles. The apparatus is so contrived, then, that the wire or rod to be tested is passed horizontally first through a magnetising helix, then through a hole in a block of wood, which supports a nicely balanced dipping needle as magnetometer. The apparatus is, of course, adapted to the size, weight, and shape of the piece to be examined. In testing plates the helix is flattened, and a number of magnetometers are mounted at short intervals on a bar, which can be moved to and fro in front of the helix and fixed at any desired distance from it. The new apparatus of Professor Wattenhofen, of Prague, for measuring the hardness of steel electro-magnetically, is a development into more practical form of a former idea of his. Its principle is that hardness of steel may be very correctly inferred from a numerical determination of its coercitive force. In its main features, his arrangement is as follows:—From one end of a balance arm are suspended successively, in a brass holder, bars of the steels to be examined (these being as nearly as possible equal in weight). The other arm bends obliquely downwards, and bears a constant weight. Motion of the beam causes a pointer to move radially over a scale, the movement being magnified by toothed wheels. One of the steel bars having been suspended, a magnetising coil, equal to it in length, is raised on a stand so as to enclose the bar, and fixed with a binding screw when it does. Then a current is sent through the coil; then the coil is released and moved gradually down, pulling the bar with it, till the latter breaks away, and the deflection of the pointer is noted at which this occurs. This affords an estimate of the hardness of the steel. For example, a bar, A, gives maximum attraction, 9·6; a second bar, B, 15·5; a third, C, 14·6. It is inferred that A is considerably harder than B and C, and of the two latter C is harder than B. Precautions are taken in the apparatus to prevent injury to the parts from the sudden recoil when the hold of the coil on the bar ceases.—*The Times.*

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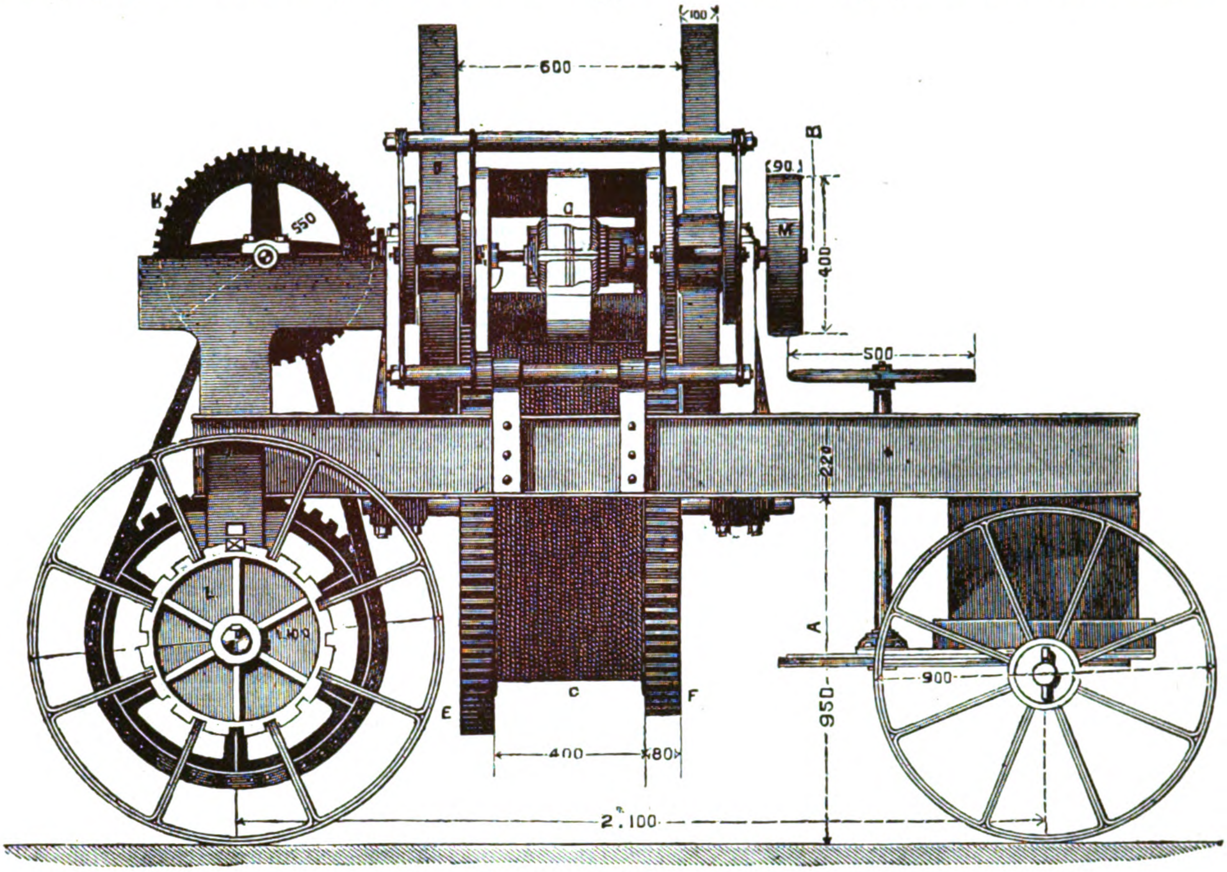
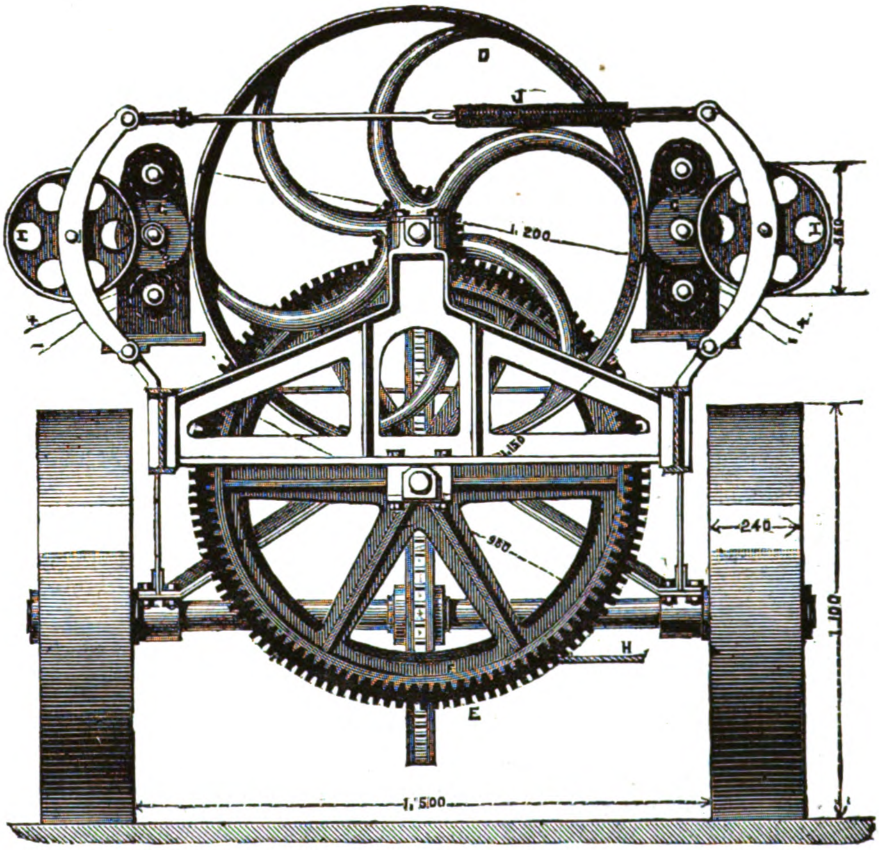
PLOUGHING BY ELECTRICITY.

The accompanying illustrations complete the article in our last issue on this subject. The carriage is of wrought iron, mounted on four iron wheels, the two side pieces being of I section. The two Gramme machines G G are mounted on a hinged frame connected to the side frames. These machines are connected at the upper part by means of a connecting-rod and a pair of india rubber rings (the friction wheel I and the spiral spring J not being found rigid enough were removed after the trial) which hold the pulleys on the end of the Gramme machine spindles against the pulleys D D. The small pulleys in the



SIDE ELEVATION



TRANSVERSE SECTION ON LINE A.B.

Gramme machines are covered with gutta-percha. The hauling drum C receives the movement of the pulleys D, by means of the pinions E or F, which give the slow or fast speed respectively. Upon the end of the spindle carrying the pulleys D is fixed a bevel pinion gearing with the bevel wheel K, upon the shaft carrying which is a pitch pinion, over which and the wheel L runs a pitch chain, by which the headland movement of the windlass is obtained. The steering of the windlass is effected by the hand wheel, as shown in front. For working, the hind wheels are fixed upon the axle by a set screw, which is loosened for travelling. The rope H is of steel 12mm. diameter, and 250 kils. in length, as used at Sermaize. [We are indebted to *The Engineer* for these illustrations].

ELECTRIC LIGHTING.

The report of the Select Committee of the House of Commons on Electric Lighting was issued on Wednesday. It is as follows :—

The general nature of the electric light has been well explained in the evidence of Professor Tyndall, Sir Willam Thomson, Dr. Siemens, Dr. Hopkinson, and others. It is an evolution of scientific discovery which has been in active progress during the whole of this century. Essentially the electric light is produced by the transformation of energy either through chemical or mechanical means. The energy may be derived from a natural force, as for instance, a waterfall, or through combustion of a material in the cells of a voltaic battery, or of fuel in a furnace. The energy being converted into an electric current, may be used to manifest electric light by passing between carbon points, or by rendering incandescent solid bodies, such as iridium. A remarkable feature of the electric light is, that it produces a transformation of energy in a singularly complete manner. Thus the energy of one-horse power may be converted into gaslight, and yields a luminosity equal to 12-candle power. But the same amount of energy transformed into electric light produces 1,600-candle power. It is not therefore surprising that while many practical witnesses see serious difficulties in the speedy adaptation of the electric light to useful purposes of illumination, the scientific witnesses see in this economy of force the means of great industrial development, and believe that in the future it is destined to take a leading part in public and private illumination. There is one point on which all witnesses concurred, that its use would produce little of that vitiated air which is largely formed by the products of combustion of ordinary illuminants.

Scientific witnesses also considered that in the future the electric current might be extensively used to transmit power as well as light to considerable distances, so that the power applied to mechanical purposes during the day might be made available for light during the night. The committee only mention these opinions as showing the importance of allowing full development to a practical application of electricity, which is believed by competent witnesses to have future important bearings on industry.

So far as the practical application of the electric light has already gone, there seems to be no reason to doubt that it has established itself for lighthouse illumination, and is fitted to illumine large symmetrical places, such as squares, public halls, railway stations, and workshops. It is used in Paris for lighting shops which require a light by which different colours may be distinguished, and has recently been used in England for the same purpose with satisfactory results. Many trials have been made for street illumination with greater or less success.

Compared with gas, the economy for equal illumination does not yet appear to be conclusively established. Although in some cases the relative economy for equal candle power is on the side of the electric light, yet, in other cases, gas illumination of equal intensity has the advantage. Unquestionably, the electric light has not made that progress which would enable it in its present condition to enter into general competition with gas for the ordinary purposes of domestic supply. In large establishments the motors necessary to produce the electric light may be readily provided, but, so far as we have received evidence, no system of central origin and distribution suitable to houses of moderate size has hitherto been established.

In considering how far the Legislature should intervene in the present condition of electric lighting the committee would observe, generally, that in a system which is developing with remarkable rapidity it would be lamentable if there were any legislative restrictions calculated to interfere with that development. The committee, however, are not in a position to make recommendations for conditions which may hereafter arise, but at present do not exist, as to the distribution of electric currents for lighting private houses from a central source of power. No legislative powers are required to enable large establishments such as theatres, halls, or workshops, to generate electricity for their own use.

If corporations and other local authorities have not power under existing statutes to take up streets and lay wires for street lighting, and other public uses of the electric light, your committee think that ample power should be given them for this purpose. There seems to be some conflict of evidence as to whether the existing powers are sufficient or not. But even in regard to local authorities it would be necessary to impose restrictions upon placing the wires too near the telegraph wires used by the Post Office, as the transmitting power of the latter would be injuriously affected by the too close proximity of the powerful electric currents needed for producing light.

Gas companies, in the opinion of the committee, have no special claim to be considered as the future distributors of electric light. They possess no monopoly of lighting public streets or private houses beyond that which is given to them by their power of laying pipes in streets. Electric light committed to their care might have a slow development. Besides, though gas companies are likely to benefit by the supply of gas to gas-engines which are well suited as machines for producing electric light, the general processes of gas manufacture and supply are quite unlike those needed for the production of electricity as a motor or illuminant.

The committee, however, do not consider that the time has yet arrived to give general powers to private electric companies to break up the streets, unless by consent of the local authorities. It is, however, desirable that local authorities should have power to give facilities to companies or private individuals to conduct experiments. When the progress of invention brings a demand for facilities to transmit electricity as a source of power and light from a common centre for manufacturing and domestic purposes, then, no doubt, the public must receive compensating advantages for a monopoly of the use of the streets. As the time for this has not arrived, the committee do not enter into this subject further in detail than to say that in such a case it might be expedient to give to the municipal authority a preference during a limited period to control the distribution and use of the electric light, and failing their acceptance of such a preference, that any monopoly given to a private company should be restricted to the short period required to remunerate them for the undertaking, with a reversionary right in the municipal authority to purchase the plant and machinery on easy terms. But at the present time the committee do not consider that any further specific recommendation is necessary than that the local authorities should have full powers to use the electric light for purposes of public illumination, and that the Legislature should show its willingness, when the demand arises, to give all reasonable powers for the full development of electricity as a source of power and light.

NEW EXPERIMENTS ON THE ORIGIN OF THE SOUNDS IN THE TELEPHONE.*

It has been observed that since speech may be reproduced in many different ways, each system of telephone may transmit it by multiple means, that is to say by the influence of different causes, and that the Bell telephone, for instance, may produce the repetition of articulate sounds at the same time by the magnetic core, by the diaphragm, by the coil, and by the wooden envelope of the telephone itself. It is added, however, that, in this apparatus, the sounds produced by the diaphragm should be the most appreciable.

It is certain that the diaphragm, by reason of its greater proximity to the ear, and of its smaller magnetic inertia, should, in accordance with the theory of its effects given by M. du Moncel, give more characteristic vibrations than the magnetic core, and the parts in connection with it. But, according to him, and in our own opinion, these vibrations would be the result of electro-magnetic attractions only when currents of sufficient intensity, that is to say voltaic currents, are employed. With the induced currents produced by the Bell telephone, currents of which the intensity may be represented by that of a Daniell element making the circuit of the world 290 times, through a telegraph wire 4 millimetres in diameter, these attractions are impossible, and we are forced to admit that the vibrations produced in this case are the result of molecular effects determined by the magnetisations and demagnetisations of the diaphragm under the influence of the magnetic core. Thus these effects would be completely analogous to those pro-

* Translated from *La Lumière Electrique.*

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duced in the magnetic core itself, and, consequently, would be due to the same cause.

It is time that it was urged, in answer to M. du Moncel, when he supported this theory, that the sounds produced directly by actions exerted upon magnetic cores could be obtained only by means of somewhat considerable electrical forces, and, consequently, could not be the result of feeble currents such as have just been referred to. The experiments of M. Ader have demonstrated that speech could be very distinctly reproduced by means of an iron wire; but for this purpose it was necessary to employ from three to six Lechanché elements. In order to overcome this objection, M. du Moncel undertook a series of experiments which showed that speech could be clearly reproduced by the currents of an ordinary Bell telephone when the receptor was constituted by a fragment of watch-spring strongly magnetised and attached by one extremity to a board. If to this spring is adapted a helix of very fine wire, placed against the board, and allowing one end of the spring to project, speech may be heard very clearly, more clearly even than with a speaking microphone, when the board is applied to the ear. In this case it is quite evident that molecular vibrations alone can occur, and yet such feeble currents as those employed suffice to reproduce speech. It is necessary, therefore, to regard the old theories of acoustics as being no longer at the level of actual science; and, whatever a few obstructive *savants* may say, they will in future have to take into consideration molecular movements and the sounds that may result therefrom.

Mr. H. Wildbrand has recently published, in *l'Electricité* of June 5, certain experiments which are most conclusively in favour of the theory here set forth.

F. G.

CORRESPONDENCE.

DUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It will probably be deemed a sufficient answer to Mr. Stearns's letter of the 5th inst. inserted in your last issue that I annex a copy of a letter written by my solicitors on the 26th April, 1878, to Mr. Stearns's solicitors.

So long ago as 1875 Mr. Stearns was informed, in answer to a threatening letter from his solicitors to me, that I denied that my apparatus was an infringement of his patents, and he is well aware that in 1876 I duplexed some of the Eastern Company's cables, in accordance with my patents after he had failed to do so with his invention.

The advice which Mr. Stearns has received that "there is no sufficient legal evidence that Mr. Muirhead has infringed his patent" is precisely in accordance with the legal opinions given to me, and it may be added that there never will be any such evidence for the best of reasons, viz., that my system is not, in fact, an infringement of Mr. Stearns's or anybody else's patent rights.

If your correspondent, "N. N.," will give the names of a few of the "many persons" referred to in his letter I shall be much obliged. I was not aware of their existence.

One might, however, say that a patentee who had the Western Union Telegraph Company, the engineer of the Postmaster-General, and the general manager of the Anglo-American Telegraph Company, as his staunch friends and supporters, and had obtained an agreement for £1,000 a year with the Eastern Company if he duplexed their lines was not wanting in "influential backing."

If Mr. Stearns has been unfortunate it is surely not from lack of powerful friends.—Yours, &c., J. MUIRHEAD, JUN.

Westminster, 18th June, 1879.

(COPY.)

60, Threadneedle-street, London,
26th April, 1878.

DEAR SIRS: We think it right to inform you that our clients, Mr. John Muirhead, jun., Mr. Herbert Arnaud Taylor, and Dr. Alexander Muirhead have now completed the application of their Patent Duplex Apparatus to the Direct United States Telegraph Cable between Ireland and Nova Scotia with perfect success.

If Mr. Stearns desires to take any action in regard to the manufacture or use of the apparatus we are ready to accept service of process on Messrs. Muirhead and Co.'s behalf, and to facilitate an early decision on the rights of the parties, and to avoid needless trouble and expense they will admit the making and using of the apparatus within the jurisdiction of the High Court of Justice. They will also, if your client wishes, procure for him an inspection of the apparatus at Ballinskelligs, or shew him a model of it in London, where it was manufactured. We thus formally challenge Mr. Stearns to support his alleged Patent rights, and shall make use of this letter hereafter in case it should be thought necessary to do so.—We are, dear sirs, yours faithfully, (Signed) BIRCHAM and Co.

Messrs. Wilson, Bristows, and Co.,
1, Copthall-buildings, E.C.

MAGNETIC PENDULUM EXPERIMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Secure the armature of a magnet to a knitting needle, and suspend this that it may oscillate freely in front of a *permanent* magnet. To the upper end of the needle fix a piece of fine silk, bring this down and secure it to a needle (interceptor) so placed that at each oscillation it will cut across the magnetic field. Small wire pegs prevent the armature from actual contact with the magnet, and also limit the amplitude of the oscillations. The "interceptor" works on points to reduce friction to a miuimum. By the attraction of the magnet the armature moves towards the pegs, but, just as it is about to touch them, the "interceptor" cuts the field, and the pendulum carries it back.

If the resistance offered to the "interceptor" should prove to be less than the direct attracting action of the magnet, then the pendulum would continue to oscillate. In my comparatively rough model I have caused the pendulum to swing so nearly to the same point each time that it requires a magnifying glass to see the loss. Lastly, the power is regulated by an extra armature, which lies across the poles, and can be shifted back over a graduated scale.

SPECTRUM ANALYSIS OF THE MAGNETIC FIELD.

Has this been carefully studied by physicists, and, if so, with what results? Would the so-called lines of magnetic force be lines of interference? We have a light spectrum, a heat spectrum, why not a magnetic spectrum, for I take it that magnetism is only a differentiation of a force.

DISC EXPERIMENT.

Rotate rapidly a disc of iron, having a steel pivot, on any smooth surface. After a few oscillations it will spin horizontally. Then place the poles of a horse-shoe permanent magnet underneath, and it will immediately *incline away from the magnet*. Is this repulsion?—Yours, &c., J. W. WETHERELL.

Raughtra, St. Levan, June 13th, 1879.

ACTION OF MAGNETISM UPON LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Is a ray of light influenced by magnetism? or, in other words, will a magnet attract it?

During some experiments I made years ago I noticed some effects which led me to think there might be electro-chemical or magnetic rays emanating from the sun, and possibly also from the other celestial bodies. The idea may, at first sight, appear absurd, yet, without proof to the contrary, I shall adopt this theory. I have fitted up some apparatus to try the experiment, and now only await the appearance of the sun, which seems determined not to come-forth.—Yours, &c., ιχθος.

CODES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "Non-Coding Merchant," who prides himself on the employment of short words, appears to overlook the fact that his simple messages are rendered possible only by the information which is obtained by a code, and without which he would not know what prices are current and what is the state of the market.—Yours, &c., S. B. E.

June 17th, 1879.

ANSWER TO CORRESPONDENT.

C. L. B.—No doubt Tellurium would be an excellent negative in a thermo-electric arrangement; but its high price (16s. per dram) would almost certainly preclude its application in this direction.

THE SILVERTOWN COMPANY.—On Thursday last, the Delegates of the International Telegraph Conference visited, by invitation, the India Rubber, Gutta Percha and Telegraph Works Company at Silvertown, Woolwich. The visit will be referred to at greater length next week.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, Strand, London, W.C.

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THE INTERNATIONAL TELEGRAPH CONFERENCE.

The work of the Conference is progressing favourably, but it seems that the public is hardly cognisant of the method of procedure, hence some of our readers are wondering why no description of the work done has yet been given. In the first place the meetings of the Conference are not open to the public, and only such matters as the members deem desirable are permitted to make their appearance in the columns of the unofficial Press. It is a question of honour that no one present divulges for the purposes of publication the proceedings of the meeting. We think the course adopted a wise one in not publishing the debates on each question; indeed this would be difficult, as each question is in the first place submitted to a committee, and when it has been thoroughly and exhaustively discussed, a report is presented to the full meeting containing the results of the discussion and the suggestions of the committee. The work of the Conference has, up to the present, been almost exclusively that of committee, and such questions as those relating to rules, tariffs, and codes are receiving consideration. The results, as above stated, will be formulated for discussion in full Conference. Practically there has been as yet only one full sitting, that on June 11th, the opening meeting on the 10th being wholly of a formal character. We are sorry to see that the cry of "Wolf, wolf," when there is no wolf has again gone forth, and that several letters have appeared in *The Times* on the subject of the number of letters to be allowed per word. We shall hardly be accused of divulging secrets if we say that the action these letters contemplate has never entered the minds of the delegates—still less found a place in their proceedings. The public need be under no alarm, the tendency of the work, entrusted as it is to able and practical men, is to free rather than to restrain, to consider the claims of the public rather than those of the telegraph administrations, and to give all that can equitably be asked; the danger, in fact, being that too great liberty will be given, which renders it difficult for private enterprise to compete with the Government administration. We trust to be able from time to time to give our readers as early information as can be obtained of the real work of the Conference.

FEMALE TELEGRAPHISTS.

Describing a typical woman of his time Pope said of her

Offend her and she knows not to forgive,
Oblige her and she'll hate you while you live.

The Atossa of to-day is of a different character; she may not forgive an affront, but she certainly will not resent an obligation. She commands—we had almost said demands—a large share of man's philanthropy, and claims all the privileges of her sex into the bargain. If, however, one half the verse has lost its terrors, the other half has grown more alarming. No one can nowadays speak a word of wholesome, if it happen to be unwelcome, truth about woman and her rights except at the risk of incurring not merely her personal disfavour, but the fervid denunciations of those well-meaning men who have lately espoused her cause. It is not without some fear and trembling therefore that on the question of employing females as telegraph operators, which has been under discussion in the daily newspapers, we venture now to express an opinion. To set ourselves right with our readers, male as well as female, we hasten to say that we have the highest possible opinion of women, desiring above all things to see them—comfortably married. Further, we are prepared to recognise the hard facts of our social relations; and, although not feeling sure that the telegraph-machine, any more than the sewing-machine, tends to the fulfilment of woman's higher vocation, we approve of her employment, under favourable conditions, as a telegraphist.

Addressing ourselves, however, to the practical bearings of the question, we shall be compelled to point out when and why the conditions are not always favourable. The ladies themselves who have been laying their grievances before the public Press have chosen to disregard any conditions whatsoever. The burden of their complaint is that the females employed in the Government Telegraph service are being reduced in numbers, and that all vacancies are being filled up by males. Some eight hundred or more of their sex, they say, were employed as telegraphists, thereby befriending "that large and increasing class of women who must always be self-supporting"; the public have been

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"quite satisfied" with this arrangement; *therefore*, to the public we appeal as to whether "it is their wish" that the arrangement shall be upset. This, briefly, is the sum and substance of their contention. We may remark upon it in passing that it does not seem so certain that the public are "quite satisfied;" one newspaper distinctly alleging that it is well known that numerous complaints have been made by the mercantile public against the employment of females at public telegraph offices. But what we are concerned with just now, is their implied *right* to be employed, and their appeal to public sentiment as sole arbiter, regardless of those practical and humane considerations the potency of which has come out plainly in the course of the discussion, and must have been perfectly well known beforehand to the correspondents themselves.

The distinction between what we have referred to as "sentiment" and what as "humane" is illustrated in the answer given to a parliamentary champion of woman's rights the other evening who taxed the Government with cruelty in reducing the number of female telegraphists. "I am myself," replied the Postmaster-General, "very favourable to female employment, and desire to see it extended." Standing by itself, this statement gives an unqualified approval of the current sentiment that the earning of wages is of itself a blessing to women, and that to render them self-dependent will, somehow or other, elevate them. He went on to say, however, that in the Postal Telegraph service it had been found that the more arduous duties, especially night duty, bore too heavily upon the males, whose numbers had consequently to be increased, and a proportionate reduction to take place in the number of females. This we regard as a humane consideration; and it is one which we should rejoice to see exercised a little oftener in the interests of women themselves in callings which are their legitimate and undisputed property. But if it come to a question whether a certain number of women shall be maintained in a particular calling to the physical detriment of the men; and if it cannot be shown that there is *no* alternative between slow starvation on the one hand and slow killing on the other, clearly the plight of the men is entitled to some amelioration. Women cannot yet afford to see men worked off the face of the earth. It is certain that all men must work; but it is not necessary, nor desirable, that all women should; nor that men should do none but noxious work in order to let women do the rest.

Applying these reflections to the case of the telegraph operators at the Central London Office, we have some reliable evidence to go upon. Several descriptions of that gigantic establishment have appeared in print since 1870—notably one by Mr. Anthony Trollope two years ago, and another quite recently by Mr. J. Munro, C.E. Both gentlemen tell the same story as to the good treatment, general comfort, and well-being of the female *employées*. The evidence moreover satisfies us that the present complaints about overwork arise from the natural growth of business, and that the females are tacitly confessing themselves unable to cope with it. But, what is more to the point, we have very detailed information about their personality. They are, we are assured, most of them young—ranging from fifteen to twenty years of age; very respectable; many of them well-to-do, evidently working "for the sake of pocket-money," and "returning in the evening to quite elegant homes." Of course there must be many exceptions; but taken as a body it is plain that the females here finding occupation hardly answer to the description "women" at all, much less to "that increasing class of women who must be self-supporting." It must be obvious indeed that for this and every other public service philanthropy has not and never can have much voice in the selection; and taking the facts as we find them, the fortunate ones are not precisely of that class whom at all cost it is the imperious duty of the State to befriend.

We come now more closely to the practical aspect of the question. Mr. Munro tells us that out of about one thousand operators there are still some seven hundred females, none of whom work later than 8 p.m. on week days, or at all on Sundays. "For ordinary lines, where the traffic is light, female clerks are," Mr. Munro considers, "even better than male clerks." This is no doubt true, just as it would be substantially true of most other employments. But when he goes on to tell us that all the night traffic, all the urgent and prolonged strain of the busy lines, as well as all the Sunday work, can only be dealt with by the men, his testimony in favour of the female operator—as such—loses much of its weight. At all events we are not surprised that continued banishment from day duty, and unremitting labour at high pressure have told their tale upon the men, and have at length necessitated what Mr. Munro calls "differentiating" the work—that is to say giving the male clerks a reasonable turn at the lighter kind. This is being done, not by discharging anybody, but simply by taking on males as vacancies occur among the females. That the adjustment is being carried out very slowly is evident from the fact that Mr. Trollope spoke of it two years ago as a process which "he feared" would continue for some time to come. Perhaps his fears would have been less pathetic had he paid his visit in the night time. We commend this suggestion to wandering authors in search of copy. The outlay of a tithe of that gush which Mr. Trollope expended on the interesting persons whom he saw at midday, if bestowed on the picture presented at midnight would have roused feelings of a somewhat sterner kind. At the age of eighteen, Mr. Munro tells us, the male clerk is liable to night duty—liable, that is, to have his days turned into nights; his natural hours of rest into hard and sweltering toil; to grow up dreading sunrise as the chilly signal for putting out all the gas, and hating the sunshine as the one hindrance to his makebelieve sleep by day. We can willingly credit the Government with rendering this part of the common experience of every male telegraphist as tolerable as may be; but at best it must be bad; and the thing that strikes us with wonderment is that from his female fellow servants there comes not one word of sympathy, but only fretful protests at any attempt to make it less frequent and more endurable.

Some details of the relative wages and the rates of sickness among the male and female clerks are furnished by Mr. Munro, but as their respective cheapness is not now in dispute we need not examine these figures. Nor need we make any invidious comparisons between the fitness of women and men as operators. What the *Standard* said the other day, on this latter point, was sheer nonsense—said in deference to prevailing sentiment by someone who evidently knew better. The operations of telegraphy are *not* to be compared with the dexterities of lace-making;—nailmaking would be a long way nearer the mark. The simple truth really amounts to this: The art of telegraphy can be learnt by most young persons, whether boys or girls. Once mastered, however, there is, as regards dexterity, nothing to choose between them. As regards docility, steadiness, and good behaviour, the women in this, as in all other employments, carry off the palm. But the dexterities and docilities are not everything. On the

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question of trained intelligence, special or technical—a quality much to be desired in the telegraph clerk—the writers we have quoted from are entirely silent. But they are precise as to the fact of hard work having to be done, growing harder year by year; as also to the inexpediency of imposing it, and it alone, upon the males.

This is the lesson which the Government has learnt by experience; and it is one that was confirmed by the longer experience of Telegraph Companies while they had a separate existence. Their practice, it is true, was not uniform, one company employing females only at small offices; another at the larger offices, but not at all at public offices large or small. One company after a long trial in their chief office ended by displacing all the females and employing a much smaller number of men; whilst another—dealing mainly with local town traffic—employed females exclusively. The companies, in short, exercised their discretion; and in a matter which, as we have shown, is mainly administrative, the Government authorities ought to be allowed to exercise theirs, whether the public on sentimental grounds "wish it" or not.

THE INTERNATIONAL TELEGRAPH CONFERENCE.

DINNER AT FREEMASONS' TAVERN.

The Joint Reception Committee of the Post Office and the Conference gave a banquet on Tuesday night at Freemasons' Tavern to the delegates at the International Telegraph Conference of London. Mr. J. Pender, M.P., presided, and amongst the invited guests were:—General Lüders, Dr. Brunner v. Wattenwyl, M. Vinchent, Colonel Champain, Dr. Siemens, M. Nordlander, M. Frey, Signor D'Amico, M. Richard, Mr. Patey, M. Staring, Count Wimpffen, M. Salmonovitch, M. Gibbs, Captain Honcke, M. E. Musurus, Mr. Benton, M. Robescu, M. Gumbart, M. Kara, M. Granfeld, M. Bugge, Mr. Moll, Mr. J. W. Fuller, Captain Suenson, Captain Hedemann, Mr. L. Wells, Mr. Gerhardi, Mr. Nielsen, Mr. Julius Beer, M. Despecher, Cav. Berliri, Colonel Holland, M. Magalle, M. le Camus, M. Yoshikawa, M. Radoycovitch, M. Salmond, M. Hirayama, M. Nakano, M. Akerlund, M. de St. Martial, M. Curchod, Mr. Fischer, Dr. Lasard, M. Eschbaecher, M. Koller von Granzow, F. de Otin, Herr Scheffler; Mr. Brassey, M.P.; Sir S. Waterlow, Bart., M.P.; Sir Tollemache Sinclair, Bart., M.P.; Mr. Dodds, M.P.; Mr. M'Lagan, M.P.; Mr. H. Edwards, M.P.; Dr. Cameron, M.P.; Mr. Goldney, M.P.; Mr. Samuda, M.P.; Mr. Yeaman, M.P.; Mr. Cartwright, M.P.; Mr. Orr Ewing, M.P.; Mr. Forester, M.P.; Mr. M'Arthur, M.P.; Mr. Puleston, M.P.; Mr. L. Bell, M.P.; Mr. Charley, M.P.; Lord Tenterden, Lord Houghton, Lord Bury, Sir D. Gooch, Bart.; Sir E. Hertslet, Marquis of Tweeddale, Hon. A. Ponsonby, Baron Reuter, W. Thornton, C.B.; Admiral Sir Geo. Richards, Mr. Wm. Forster, Sir W. Thomson, Mr. Andrews, General Tremenheere, Mr. H. D. Pender, Captain Mayne, Mr. E. Bright, Mr. Weaver, Mr. L. Clark, Professor Abel, Mr. Stronge, Sir James Anderson, Mr. Bevan, Sir Wm. Milne, Mr. D. Currie, Mr. D. Gibbs, Sir C. Bright, Mr. Erichsen, Professor Hughes, Alderman Cotton, Mr. Preece, and Major Wood.

The vice-chairs were occupied by Sir James Anderson, Mr. Erichsen, Mr. Weaver, Mr. Preece, Captain Mayne, Mr. Andrews, and Major Wood.

The toast of "The Queen" having been duly honoured, the CHAIRMAN proposed, "The Sovereigns and Presidents of those States represented at the Congress."

The CHAIRMAN then gave "The Health of the Members of the International Telegraph Conference." He said: Gentlemen, allow me, on behalf of the Submarine Telegraph Companies to give you a warm and hearty welcome [prolonged cheering]. The duties to which the delegates are called are of a very onerous nature, and, looking to the position and character of their representatives, the Governments taking part in this Conference have shown by their selection that they are quite alive to the importance of their mission. The importance of telegraphy is such, and the growth of it has been so rapid (for it is little more than thirty years ago that it was practically developed), that it has been impossible to confine it within the limits of nations; hence the establishment of this Conference. Telegraphy has beaten time and annihilated space, yet it is still in its infancy [cheers]. Its future growth will be materially influenced by the deliberations of this Conference. The value of telegraphy to diplomacy we can well understand. In a moment Governments are made aware of difficulties which often suddenly arise, and which if not promptly checked might be fraught with disastrous consequences. I may say, without fear of contradiction, that the commerce of the world is now carried on through the electric wire, and when we measure this by the millions upon millions of money required for these operations we can form some idea of this great power. Every morning the merchant, be he where he may, learns the value of produce or commodities in the most distant parts of the globe. In a moment a transaction is conceived, and a few minutes will see the operation completed. By this agency it is evident how rapidly capital can be turned over; and as we all know that time is money, so we all know that the rapid turn-over of capital enables you with small profits to realise large gains [cheers]. In these times transactions can be concluded in a few hours which in bygone days would have occupied as many months. It is difficult to realise all that has been done, and will yet be done, by this great agency which has suddenly sprung up amongst us; but it is not difficult to appreciate the enormous advantage which the world has reaped and is reaping from it. When we ponder these facts, it is not difficult to understand the great importance which must be attached to the deliberations of the Conference. There are at present in existence about a million and a quarter of miles of land lines, representing a cost of some forty millions of pounds. This vast network has been constructed and worked by the European Governments, excepting one company, the Indo-European Company, which is more or less controlled by Governments. The submarine cable companies, whose home, I may say, is in England, are not entitled to vote at the Conference. Government delegates alone have this privilege, but the systems of the submarine cable companies are so widespread, and are so vitally essential to telegraphy considered as a whole, that I may be permitted to express the view that it is desirable the Conference should well consider the position which the Companies occupy, and that in their deliberations they should consider conditions which affect them most materially. In reduction of tariff, for example, the Governments might properly reduce rates on their own lines to a point which would be barely remunerative; but unless the Government or Governments are prepared to take over the companies' lines they must bear in mind that those investors who have established these companies are entitled to a fair return for the capital they have invested [loud cheers]. Fifteen years ago there was only 2,000 miles of submarine cable in existence, and that was of a very imperfect nature. There are at this day about 66,000 miles of submarine cable, representing a capital of £25,000,000, or about two-thirds of the cost of all the land lines. The bulk of this capital has been found in England. The lines of the companies are sown broadcast in the Mediterranean; they bring us into communication with America, India, China, Japan, Australia, and New Zealand, and within a short space of time we may add South Africa. All this has not been done by the aid of Governments, but by a handful of men of enterprise. The important part which telegraphy has performed during this period of wars and rumours of wars, is best known to those who have been pulling the wires; but I believe I may state, without fear of contradiction, that had telegraphic communication been established with the Cape two years ago, when its expediency was strongly urged, there might have been no Zulu war to-day [cheers]. Do not suppose that I am blaming the Government in any way for not taking an active part earlier in the establishment of the line. I know that they have got the House of Commons to deal with, and that House is very often "penny-wise and pound-foolish." I consider this circumstance an illustration of what I say. I believe that if we had had a telegraph to the Cape two years ago, it would have saved this country at least ten millions of money, would have saved much bloodshed, and prevented a shadow coming over many a home [hear, hear]. I hope the Conference in the course of their deliberations will take into serious consideration the question of Press messages. Telegraphy has made a very great change in newspaper property [hear, hear]. Time was when the organ which professes to lead public opinion, *The Times*, enjoyed almost a monopoly of news, as it spared no expense on the means of locomotion, so as to be the first to bring, by special expresses, important intelligence into the market. Now telegraphy has laid the world open to all newspapers alike, and, as an evidence of the enterprise of the daily papers, I may mention that a very short time ago a message was received in London, by a paper published at a penny, which cost over £220 for transmission [hear, hear, and cheers]. The Press is the great educator of the people, and as it must provide a large amount of matter

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each day, I think it is entitled to large consideration [hear]. On the Atlantic systems of telegraph we are carrying Press messages at quarter rates; these messages being carried at intervals when the lines are least employed. I think a similar rate should be granted by all telegraphs; it would be a great boon to the Press, and a greater boon still to the public at large, while I believe it would not involve any loss to the telegraphs, but eventually it would be a considerable gain to them [hear, hear]. I think the question is an important one, and very well worthy the consideration of the Conference now sitting. They may rest assured that the submarine companies will heartily co-operate with them in any decision they may come to [cheers]. Personally I am a strong advocate for telegraphy being international [hear, hear]. I hope the day is not far distant when the Governments throughout the world will acknowledge the importance of this view, and see their way to the absorption of the submarine telegraph network, so as to make one great whole and entire system of international telegraphic communication [cheers] and, gentlemen, when the day comes, and I do not think it ought to be very far distant, I hope and believe it will be beneficial to the peace and progress of all the nations of the world. Looking to the power of this great agent, telegraphy—a power whose expansion we cannot yet foresee—let us hope that the result of the deliberations of the Conference will be to make its paths wider, and to aid the development and interchange of human thought throughout the world [cheers]. I beg to connect with the toast the name of M. Brunner v. Wattenwyl [renewed cheers].

M. Brunner v. Wattenwyl, delegate from Austria, who responded in French, said: The chairman has remarked that the Telegraphic Conference represents progress. I accept this compliment. What corporation, what individual, would not be flattered by the assertion of having contributed to civilisation? But this is not all. We represent another thing. Those of my colleagues who may be present for the first time at such a conference may have remarked, and those who have taken part in one before can confirm the opinion, that from the first we have always been animated by the same spirit of conciliation, that we have followed the same methods in our deliberations, and that ever since 1865 we have done the same kind of things and have had the same motives for our decisions. In concluding he expressed his belief that the greatness of England was due in a great degree to the development of telegraphs.

Viscount Bury: Gentlemen, I have been warned that, considering the lateness of the hour and the company before which I have the honour to speak, I ought to confine my remarks within the limits of a telegram and in telegraphic language [a laugh]. I will do my best to obey, but when I tell you that the chairman has entrusted to my care a toast of such importance as that of "The Colonial Empire and Dependencies of England, united by Telegraph," you will see that it is almost impossible for me to compress my remarks into the limits in which the most generous telegraphist would undertake to convey a message [cheers and laughter]. Mr. Chairman, whenever I have to consider the Colonial Empire of England, the best description of that Empire which comes to my mind is always contained in those eloquent words of the American statesman, Daniel Webster, who, speaking of the enormous extent of the English Empire, and the way in which it encircles the world, made use of these remarkable words, "that England's morning drum-beat, following the sun in his rising, girdles the world with an uninterrupted strain of the martial airs of England" [loud cheers]. Gentlemen, who could have said more, who could have said so much, indeed, in so few words? [hear, hear]. I should be content to leave my toast there, and to say that those scattered posts all over the world, of which Daniel Webster spoke, are now, by the enterprise of those around me (headed, as far as my own country is concerned, very mainly by my hon. friend in the chair)—those posts are now connected, not by the martial strains of England only, but by the more material line of the telegraph wire [cheers]. I remember the time when the American colonies, and especially the Australian colonies, were enormously distant in point of time from this country—when it took weeks to obtain an answer to a letter or a message from our Indian Empire. Now, from India you hear of events, judging by the time, even before they have occurred; and in our Australian and American colonies not one moment is allowed to elapse between the occurrence of any great event and its publication throughout the length and breadth of the land. No one can deny the enormous advantages that have accrued to this country—aye, and to the whole world—from the system of telegraphic communication which has been spread like a network over its surface. If we wish to estimate the advantages that have accrued we have only to remember the disadvantages that occur in those isolated cases where we have no such communication [hear, hear]. The Chairman has referred to the case of the Zulu war which is now going on in South Africa. He said that if there had been telegraphic communication with the Cape he believed there would not have been any war, and that millions of money would have been saved to England. Now, in the particular department which I have the honour to fill at this moment I am unable to endorse the view of my hon. friend [a laugh], but at the same time I will concede to him that if there had been a telegraph possibly there might still have been a war, but the war would have been conducted with threefold more expedition than it has now been conducted with [cheers]; and it is not at all impossible that whether it had begun or not—and I do not dispute with him on the point—it would now have been brought to a termination [hear, hear]. We have been told to-night—I am very glad to hear it, and I think I need not say to you that it is not the first time I have heard it—that we are now on the verge of establishing telegraphic communication with our South African possessions. In my opinion the Government of which I am a member will rejoice to see almost the last part of Her Majesty's dominions which still remains unconnected with us by telegraph brought within the limits of telegraphic communication. Bygones in these matters must be bygones [hear, hear]. My hon. friend said he did not attack the Government for not having taken the lead in this matter, and he was right; for I need not remind him that in this commercial country it is never the Government which has to take the lead in a commercial enterprise, but it is always left to independent enterprise to inaugurate, and that the Government's sole concern is to foster and to help [hear, hear]. Gentlemen, I have exceeded the limits of my telegram, and I will therefore only add that the toast I propose to you is "The Colonial Empire and Dependencies of England united by the Telegraph;" and if the Chairman will allow me, I will couple the toast with the name of Mr. Foster, the Agent-General of the South African colonies [cheers].

Mr. W. Foster: Gentlemen, I feel it a great personal honour, and a great official pleasure also, to respond to this toast and to acknowledge the hearty way in which it has been received; and certainly the honour that is conferred upon me and the pleasure that I feel are not diminished by the circumstance that I have—unfortunately, perhaps, considering the question that is before us—to represent a colony which is not represented at present on the Conference [cheers and laughter]. Nay, on this account perhaps I am the more bound to express my gratitude, and the gratitude of the unrepresented colonies and portions of the British empire, for the good work that is being at present done by this Conference. I cannot but feel that we can do very little at present except to express our gratitude, and to accord you our hearty sympathy [cheers]. We are like auxiliary troops, fighting upon the skirts of a large army, and we cannot but feel that, from the way in which the battle is being fought by those who are engaged in the thick of it, by this Conference will be determined the great interests which belong to us all in common in connection with this question [cheers]. And, looking to the character of the battle that is being fought, seeing that the progress of the electric telegraph all over the world is truly an intellectual progress—is the battle of mind over matter [hear, hear]—looking to the enormous conquests it has hitherto achieved, to the immense advantages it has given to the world—we cannot but have the greatest reason to hope for the success of this Conference in the future, and that the time will come when the efforts which are being made by this Conference will be successful all over the world, and that the circle which you are engaged at present in making will embrace not only the British Empire, but the world in general, within its folds [cheers]. Gentlemen, I feel, as I have said, that this is a great honour for me, and an opportunity which I am proud and happy, on behalf of the colonies I represent, to take advantage of, in order to express our gratitude and sympathy for the great work that is being done; and I hope and trust that if, on any future occasion like the present—and I am quite sure I am speaking the sentiments of a great many present in anticipating with pleasure a repetition in the future of this happy meeting [cheers]—if it should then be my duty to respond to a toast of this kind, I may be able to respond as representative of a colony that is one of those represented on the Conference [cheers].

Mr. Nielsen, delegate from Norway, who spoke with excellent effect in English, said: Gentlemen, the honour has devolved upon me of proposing the toast of "The Companies" [cheers]. I only wish I could find appropriate words to thank them for the hearty welcome and the grand entertainments which they have bestowed upon us [renewed cheers]; but I rely upon the members of the Conference to express their feelings by the warm reception which they will give to the toast [loud applause]. There are still pouring in upon us invitations to splendid and various entertainments, and they always are coupled with the names of the Post Office and the united companies; and I see in this coupling of their names—contrary to what has been stated

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before—that in this great empire the State and private enterprise go hand in hand, and I think it cannot be otherwise while the Government can be sure of the support of the people [cheers]. I see in this harmonious and unanimous welcome from the companies other things. I have been a member of the Conference from the first, and I remember that at our second meeting the companies came for admission, and they stated there as a fact that the capital invested in their enterprise was more than all the capital of all the land lines of all the Governments [cheers]. We were a little astonished at that, but after some difficulties we came to an agreement that the status of the companies demanded recognition by us, and since that time it has been more and more clear to us that the whole body of those interested in telegraphy belong to one brotherhood [loud cheers]. If you in private have a distrust of something in your heart, or if you are in any difficulty, what do you do? You go to your bosom friend and knock at his door, and you are sure to get the best advice. That is what we do [hear, hear]. We go with a telegram, we knock at the door of anyone we choose amongst our fellow telegraphists, and we are sure to have his best and most hearty advice [cheers]. In that way we get material assistance. I give the toast of "The Companies," with our best wishes for their development and progress; and that valuable assistance will continue to be rendered by them to the State; so that every current that can be brought into practice on the cables must become an agent for the benefit of the world [loud cheers].

The Marquis TWEEDDALE: Gentlemen, I readily accept the pleasing duty of responding to the toast which has just been given in such eloquent language by the honourable delegate from Norway. I can assure you that on behalf of the various companies interested in submarine telegraphy I return you my most hearty thanks, not only for the way in which the toast was proposed, but for the manner in which it has been received. I believe public companies are not in very good odour at present [a laugh]. The reasons of this are various, and I am not going to enter into them. Certainly the telegraph companies have not escaped a good deal of blame and censure. They have been described as greedy monopolists, as caring nothing for the public interests, and as being capable of anything that might conduce to their own profit and gain. Now, I do not think any other argument is necessary to disprove those allegations than that we (representatives of the companies) have met here together with the delegates representing the sovereigns and presidents of the countries of Europe [hear, hear]. I am quite sure they would not have associated themselves with us in the friendly manner they have done since the very commencement of these international conferences, if our mode of conducting business had been based on the selfish motive. None know better than those who are here as strangers this evening that monopoly has had no part in the business at all. On the contrary, there is the remarkable fact that not only are we exposed to competition from private enterprise, but that at almost every point of the business we conduct we are actually competing with the Governments themselves—not only foreign Governments, but our own Government [hear, hear], and I think nothing speaks more of the sincerity and enterprise with which the companies' affairs have been conducted than the fact that we have been able to compete successfully [cheers]. When the history of joint stock enterprise comes to be written, I think no more honourable page will be found in it than that 60,000 miles of cable have been laid by that enterprise within the extraordinarily short period of time stated by our Chairman [hear, hear]. The Chairman has referred to the agreeable relations which have subsisted from the first between us and the telegraph delegates. There is no doubt they could have done us a great deal of injury if they had taken a selfish or a narrow view of our position, but instead of that they took a broad and straightforward view, and the result has been a system of telegraph management which is equal to anything in the world for administrative skill and rapidity [cheers]. I think there is nothing left to be added to the liberality, the rapidity and efficiency of telegraphic communication. What now remains—and what interests the public far more than anything else—is the assimilation of the tariff throughout the whole world [cheers]. Now, I believe it is known that a proposition for something of this kind was intended to be submitted to the Conference on this occasion, but for very wise and prudent reasons the discussion has been postponed—merely, I believe, because the discussion is premature, and not for any other reason [hear, hear]. I think the Chairman is right when he says there would be no real difficulty whatever in establishing a uniform rate for the whole world [cheers]. I think the telegraph companies would meet the question with the same consideration and liberality as they have hitherto done, for it would not be for them to put themselves in the way of so desirable a resolution, but rather to assist it in every way in their power.

Lord HOUGHTON, in proposing the next toast, said: My lords and gentlemen, for myself and the distinguished company of visitors who have attended your hospitable board I return you our grateful thanks; and I pass with telegraphic speed to the toast which is placed in my hands. In some sense it is a painful one [laughter]. I am well aware of the obloquy which generally attaches to the names of the benefactors of mankind. In fact, I remember my friend, Lord Macaulay, saying he did not know any one man who had done serious injury to the human race who had not either hailed himself by that title, or been called so by others [hear, hear, and laughter]. I know, too, the bad sense which is generally attached to the word philanthropists—what uncomfortable people they are thought to be to all about them, and especially to their own families [laughter]. And when I add the more serious charge of being an international, you will know well how that name is regarded by the governments of Europe [laughter]; and when I tell you that the gentleman whose health I call upon you most cordially to drink is at once a benefactor of mankind, a philanthropist, and an international, I must throw myself upon your indulgence [laughter]. Perhaps you may feel that although he has been a benefactor to mankind generally, he has not been a malefactor to those who have been associated with him in his enterprises nor to the friends whom he has gathered about him [cheers]. If he is a philanthropist he has been also regarded with the deepest friendship by many men, and not least, I believe, by his own family [cheers]. And if he is an international you will not forget that his has not been a process of division—his has not been a process of separating classes—but that he has done his best to bind by the strongest cables possible the interests and the welfare of the nations of the world [cheers]. That being so, I may fairly ask you to drink his health, because there is one point beyond which I cannot forget that he has done what I believe to be the greatest of benefactions. He has applied the soundest sense to the best interests of mankind [cheers]. He has done that in a very practical way—in a way which has not only touched the general interests of nations, but also the interests of individuals. At this present moment, notwithstanding the recent disastrous times, the interest of the telegraph stands apart—it stands almost unaffected by the general distress [cheers]. My hon. friend has known how to combine individual with general interests. He has so managed the affairs of the telegraph companies that the risk is diminished to a minimum by attention to the process which he has invented [cheers]. This, gentlemen, is a fact which I believe is not only welcome to the commercial interests of this country but welcome to the interests and the heart of every man present [cheers]. I am told by an influential gentleman here that French is the language of the International Conference. I only wish my British accent enabled me to speak in that language, but I will conclude by an anecdote, the point of which rests on the great language which is common to both of us. On the arrival of the first telegram from Ireland to America there was a banquet, at which a message was sent from the company to the charming American poet Mr. Holms in these words, "We salute you," and he answered "You salute me *de Profundis*, and I answer you *sursum corda*." In the same spirit I ask you to drink the health of our eminent Chairman.

The CHAIRMAN: You have heard, gentlemen, a very eloquent speech from my friend, Lord Houghton. I believe there is no man in England—I doubt if there is any man living—who can perform the duty he has just performed so well as Lord Houghton is reputed and has shown himself able to do [applause]. He has paid me the highest compliment that a man can offer to his fellow man. I accept that compliment, but not for myself. In the course of the few remarks that I made in the early part of the evening I said there were other men associated with me, although there were comparatively few in this great enterprise of submarine telegraphy. I share with those gentlemen the great honour and the great compliment which Lord Houghton has paid me this evening; and when I say we have all but completed the work which was prophesied by a great poet so many long years ago I hope that we shall not leave the final accomplishment of it to those who follow us, but I trust that they will have the full use of the great instrument we have provided for them—the instrument which I believe is to be a greater humaniser than has ever appeared in the world's history [cheers]. I can only say that I feel proud of being associated with telegraphic enterprise, and I trust that, however commanding the position of the enterprise may be, and however much it may have benefited the nations, the managers, in bringing it up to this point, have found their reward in the knowledge that it has been a great boon to the world at large. [loud cheers].

The company then separated.

An excellent programme of music was performed during dinner by a select orchestral band, under the management of Mr. J.

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Smyth, R.A., and, after dinner, the musical arrangements were under the direction of Mr. Chaplin Henry, who was assisted in rendering a capital programme by Miss Clara Samuell, Miss Bessie Stroud, Mr. Montem Smith, Mr. M. Watson, and Mr. Winn. Altogether, the arrangements for the comfort and enjoyment of the guests were very complete—the *menu* included every delicacy—and great credit is due to the committee for the successful character of the gathering. Mr. Harker officiated as toastmaster.

COWPER'S WRITING TELEGRAPH.

On Tuesday evening we witnessed, at Waterloo Station, a very satisfactory trial of Mr. E. A. Cowper's "writing telegraph," made between Woking and Waterloo Station Telegraph Office. We have already fully described this ingenious and novel instrument in our columns, so that no fresh and complete description is necessary. The distance from Woking is 26½ miles. The wires used were overhead wires, one of No. 6 gauge, and one made up partly of No. 11 and No. 8. The batteries employed were fifteen elements on one line and ten on the other of Fuller's bichromate elements.

The sending part of the instrument was at Woking, and the receiving at Waterloo. At 7:15 Woking commenced to speak, and at 7:18 had sent a message of forty-five words without the slightest hitch and each word being distinctly written. Several other messages followed. The line wires are not in the best of order, and there was a slight movement of the syphon pen when it should have been at rest, indicating either slight contact or induction. The syphon seemed always to act easily, both as regards movement and flow of ink. When the instrument is not in use, to prevent the ink, which is blue aniline dye, from drying, the end of the pen, which is simply a bent tube of glass, a little larger than those used in Thomson's syphon recorder, is lifted up and then allowed to rest in a small trough with a damp sponge in it, so that the ink may continue to flow, or the pen is allowed to rest on the paper, which is made to move very slowly. Besides the resistance of the line, some resistance coils were inserted to increase the resistance to 500 and 300 ohms, to tone down the strength of the current, as rather more battery power was used than would be employed on a more perfectly insulated line. The local battery, to magnetise the soft iron needles, was five bichromate elements. The adjustment of the springs which act against the pull of the needles is made simply by moving the castings which clip the spring to move round its centre by hand without any screw arrangement. As the sending part of the apparatus was at Woking, we were not able to witness the operation of sending, and any messages to the sender had to be sent by the ordinary telegraph instruments, but when a complete pair of instruments is made the means of interrupting and stopping a message and ordering a repeat will be provided.

Messrs. Elliott Brothers and the India Rubber, Gutta Percha, and Telegraph Works Company are each about to make sets of instruments, and more extended trials will no doubt then be made. The instrument has not yet been tried on submarine or subterranean lines, but Mr. Cowper thinks that as it is only a difference in the strength of current that is required, and not an entire discharge or reversal, the instrument will not be so much affected as others by electrostatic capacity. As regards its use, short distances, where the expense of two wires instead of one bears a small proportion to the total of instrument and office expenses, are evidently the localities for such an instrument, and Mr. Cowper points out that between head offices and factories and works where important instructions have to be sent to foremen, the advantage of writing direct will be mostly felt. The instrument is most ingenious and entirely novel, and we think Mr. Cowper deserves every success in a work which he has perfected after two years of thought and work.

ON CODES.

BY "AN EX-TELEGRAPH OPERATOR."

The following letter on this important subject was received just as were going to press :—

Will you allow me to offer a few remarks upon a subject that I see is again being discussed in your columns—the subject of codes and code words.

As one who has had considerable experience as a telegraph operator, I feel an interest in the subject, and as one who is a telegraph operator no longer I can speak without much fear of the consequences, though I hope I shall make no assertions that my late fellow servants in the telegraph companies will not be ready to corroborate. Your correspondent, a "Non-Coding Merchant," does not state the matter a bit too forcibly when he says that "telegrams made up of long code words take twice or three times as long to transmit as ordinary plain language messages." Take any of the telegrams that he has given, and the three words of which they are composed would, I find, require about, on the average, twenty signals to transmit them. But take three such words as Mr. Whitelaw has provided for the comfort of telegraph operators, and how many do they require for transmission? *e.g.*, "Ghafdjdaki," "Hamzyzmich," "Hachlamali." By referring to the Morse alphabet it will be seen that the first of these requires thirty, the second thirty-two, and the third thirty signals for transmission, *i.e.*, ninety-two in all, or four-and-a-half times as many as are required by any three of the words such as your correspondent states that he has been in the habit of sending. It is, I think, a noticeable fact that the great majority of commercial words and terms are short—very short—some few only, like "*disbursements*," containing more than *six* letters, and even these words, under the influence of the double rate charged for words of over ten letters, are gradually being supplanted by shorter words in plain language messages.

Why, then, should merchants be allowed to ransack a dozen languages in search of long code words?

I maintain that the telegraph companies are in duty bound to protect their servants from the largely increased labour long code words bring.

Mr. Whitelaw's compiler, I observe, states in his introduction: "The public has recently been informed by a leading telegraph official that the great difficulty with telegraph operators is to get them to spell and not read, and that a familiar word carelessly looked at is often mistaken and sent for another familiar word of similar appearance." And from this he deduces an argument in favour of long code words. There are, I am aware, some such instances where one familiar word has been mistaken for another, especially if bad writing has in any way assisted the operation. But let common sense say a word or two on the matter. And, taking the physical powers of telegraph operators into account, I would ask whether a familiar word is not more likely to be correctly transmitted than an unfamiliar word; and, further, I would ask whether mutilation in an unfamiliar word is not more mischievous than in a familiar word? There is, moreover, a third alternative. What if an unfamiliar word be mistaken and transmitted for a familiar word—such a word, for example, as "actitation" being read "agitation" (both of which appear among Mr. Whitelaw's code words). For myself I can say that, had I received such a word, I can conceive many circumstances that would have induced me to believe that my co-operator had transmitted the word in error, and I should therefore have made what I considered a necessary correction—fines or reprimands notwithstanding—especially if a large number of messages were likely to follow.

But, leaving this element of error out of the question, if we confine our attention to the physical capacity of telegraph operators it should not be forgotten that it is not one nor ten messages only that telegraph operators have to transmit within a given period. In that case the temporary strain upon their attention might be readily borne; but when their minds are weary with their dull task they are then very likely to mistake an unfamiliar for a familiar word, or by making a dot into a dash, or a dash into a dot, and failing to make a pause at the exact time, a word is produced which neither Lord Dundreary nor any other fellow can understand, though in no way worse than some code words. It is, therefore, I venture to think, almost as much for the interest of coding merchants as it is for the interest of others that code words should be fairly familiar and not unnecessarily long.

It cannot be too often pointed out that at least half the errors in telegrams are caused by bad writing rather than imperfect signalling.

But, without tracing out the various causes of telegraphic errors, I cannot help thinking that our work will compare very favourably with that of the printer. Some of your readers must be well aware of what feats a printer can perform when he is employed to put into type a number of strange code words.

There is, however, a test of the difficulty and liability to error of such words as are contained in Mr. Whitelaw's collection, as compared with ordinary plain language that is within easy reach of all.

Let any one try the experiment of copying a hundred code words, such as I have given above, while a friend is copying an ordinary article from a newspaper, and he will find that his friend will copy from 350 to 400 words by the time that he has completed his task; and whilst his friend will probably have copied his without a single mistake, the chances are greatly in favour of his having two, three, or more misspellings or corrections in the 100 words, unless he is a more than ordinarily careful copyist.

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The compiler of the work in question states that it has undergone six revisions with a view to the elimination of all similar roots.

Surely the endings were also worth some attention. Not a few of them apply to hundreds of words. And yet who will assert that such endings as "asti," "ava," "esti," and "eva," in Italian, as "es," "ein," and "ete," in Greek, "ias," "iens," in Latin, and many others, are not far too much alike to be safe, forming, as they do when severally joined to their proper roots, long words that have but the slight difference of a dot or two in the signals employed to transmit them.

This, however, is rather a matter for coding merchants, who sometimes seem as if they would prefer a little risk, only the telegraph companies and telegraph operators should not be made to suffer for their whims. Nor should they if I had my way in the matter; for let such words as "Ghafdjdaki" be accepted only at the sender's risk, without repetition of any kind unless paid for, and let telegraph operators be advised that fines would not be inflicted for mistakes in such words, and I would engage, with these conditions, to banish such telegraphic pests in a month.

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Cuba	8½,	¾	—	—
Do. Ten per Cent. Preference	16,	17	16½	16½
Direct Spanish	1¾,	2¼	2	2
Do. Ten per Cent. Preference	10¾,	11¼	—	—
Direct United States	10¼,	¾	10½	10½
Eastern	7¼,	¾	7¾	7¼
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	101,	103	102½	101¾
Do. Six per Cent. Preference	11½,	12	11½	11½
Eastern Extension	7½,	¾	7½	7½
Do. Six per Cent. Debenture	107,	110	109¾	109¾
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4½,	¾	5	4¾
Do. Six per Cent. Preference	10½,	¾	11	10¾
Great Northern	8½,	¾	8¾	8 9-16
Indo-European	20,	21	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	9½	9½
Reuter's	9,	10	—	—
Submarine	225,	235	227½	227½
West India and Panama	1½,	¾	1 9-16	1 7-16
Do. Six per Cent. Preference	8,	½	8½	8½
Western and Brazilian	3¼,	¾	—	—
West. Union Seven per Ct. 1st Mt.	112,	116	—	—
Do. Six per Cent. Sterling	103,	105	—	—

TRAFFIC RECEIPTS FOR MAY, 1879.

Companies.	May 1879.	May 1878.	Incrse.	Decrse
Direct United States Telegraph Company	15,970	—	—	—
Eastern Extension Telegraph Company	25,845	23,844	2,001	—
Eastern Telegraph Company	38,371	33,650	4,721	—
Great Northern Telegraph Company	18,917	—	—	—

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NOTES.

THE TELEGRAPH IN SOUTH AFRICA.—An Indian paper mentions that bamboo poles for use as telegraph posts are being sent to Natal from Madras.

AN EVENING WITH THE DELEGATES.—On Friday, the 20th June, a large and brilliant assembly gathered together at 18, Arlington-street, the house of Mr. J. Pender, M.P., to meet H.R.H. the Duke of Cambridge and the Delegates of the International Telegraph Congress.

THE ELECTRIC LIGHT.—An exhibition of electric light apparatus is being held at the works of Messrs. Emmerson, Murgatroyd, and Co., Heaton Foundry. The electric current is supplied by a Gramme machine provided by the British Electric Light Company. The lamps are those of Serrin and Werdermann.

PROPOSED CHEAPENING OF METROPOLITAN POSTAGE AND TELEGRAMS.—We understand the authorities of the Post Office have it in contemplation to issue some new and important regulations. Amongst the changes which it is intended to make is included the establishment of telegrams at a sixpenny rate within the London radius, and to be extended to the country in course of time.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE WORKS.—The Delegates of the International Telegraph Congress, and a number of friends, accepted the invitation of the Telegraph Construction and Maintenance Company to visit the magnificent cable ship Scotia, the works of the Company, and finally to dine at the Ship Hotel, Greenwich, on Wednesday, the 25th June. We are compelled to leave the report of this visit to our next issue, in the meantime stating that we consider it to have been most successful, the only drawback being the state of the weather.

THE BROOKS UNDERGROUND TELEGRAPH CABLE.—The system of Mr. Brooks differs from all others in the fact that the material employed for maintaining the insulation of the line is a liquid—paraffin oil—which is known to possess, for this purpose, qualities of the highest order; and in laying it the wires—thirty, forty, or fifty, as may be required—covered with cotton binding, are placed in an iron pipe, conveniently located, and the pipe line filled with oil—allowed to run in until full, the maintenance of the supply being assured by providing an elevated vessel of the material at intervals, so that a constant pressure will be kept within the pipe. This is practically all there is about it, and its extreme simplicity appears to be not the least of its merits, as one of the great objections advanced by the advocates of the past system has been the great expense of laying and maintaining underground lines.

WILSON'S PATENT CONSTANT CELL.—This battery, which has been reported upon very favourably by certain authorities, is stated to have an E M F of about two volts per cell, with an internal resistance less than one ohm, and to be of remarkable constancy; whilst its action, under ordinary circumstances, is maintained for a very considerable period, in comparison with that during which a bichromate cell will work without attention. We are unable to give particulars as to the solutions used; but it appears that binoxide of manganese is used, indirectly, as the depolarising agent. The battery is constructed with a glazed cell, the lower portion of which is divided into two concentric compartments. The inner compartment contains a porous jar of about the same height as the cell, and also a magma of binoxide of manganese, which thus surrounds the lower half of the porous vessel, which contains a strip of carbon constituting the negative element. The positive element is a zinc cylinder, which rests on the partition, and thus occupies the upper portion of the outer cell.

LIGHTNING RODS.—Mr. R. S. Brough states, in the *Journal of the Asiatic Society of Bengal*, Vol. xlvii., p. 191, that a thin wire, of either copper or iron, would, for conductivity, suffice for the loftiest building; but a thin conductor would be dangerous, because it would be fused by a heavy discharge of lightning. To the problem as to the relative sectional areas to be given to copper and iron rods, the answer usually given is, that an iron rod should have four times the section of a copper rod, determined from ratios of the conductivities and fusion points. But this simple treatment neglects the influence of the rise of temperature in increasing the electrical resistance of the metal, the difference between the specific heat of the copper and iron, and the fact that the iron rod, being made several times more massive than the copper rod, it requires a proportionately greater quantity of heat to increase its temperature. These omissions introduce an enormous error into the result, and the author determines, from the corrected consideration, that the sectional area of an iron rod should be to the sectional area of a copper rod as 8 : 3.

PATENT COLLIERY SIGNALS.—The patent block signals introduced by Mr. Bagot in 1878 have the disadvantage of requiring a battery to work them; this having been found inconvenient where the men are not acquainted with electric telegraph apparatus, the patentee has invented a bell that signals equally well, electrically, *without any battery*. By merely pressing down the key, a current is generated in the coils in front of a powerful magnet; the current is exactly of the same length of duration as the time occupied in depressing the key. It follows, therefore, that for each depression one stroke is simultaneously given at the pit bank and engine room, and that no half or uncertain signals can be given. Four signals can be sent in one second. The most important feature in the invention is that, in the event of wires getting in contact, no signals are given, and no one but the person actually in charge of the key can signal, since, unless the key be depressed, no current exists. This removes two grave objections to electric signalling in collieries, and provides the maximum safety with economy, as the cost of maintenance is dispensed with.

ON THE FORMATION OF HYDROCYANIC ACID IN THE ELECTRIC ARC.—The following is an abstract of a paper recently presented to the Royal Society by Professor James Dewar, M.A., F.R.S.:—A series of experiments favouring the conclusion that the so-called carbon lines are invariably associated with the formation of acetylene (as suggested by Plucker, Angstrom, and Thalén) induced me to make some experiments to ascertain whether this substance can be extracted from the electric arc, which invariably shows this peculiar spectrum at the positive pole, when it is powerful

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and occasionally intermittent. For this purpose the carbons were used in the form of tubes, so that a current of air could be drawn by means of an aspirator through either pole, and the products thus extracted from the arc, collected in water, alkalies, and other absorbents. Gases may be led through one of the poles, and suction induced through the other, in order to examine their effect on the arc. The following experiments record the results obtained by means of the Siemens' and De Méritens' magneto machines. Experiment 1: Drew a current of air by an aspirator through the drilled negative carbon, and passed the gases through potash and iodide of potassium and starch paste; found no nitrites; potash contained sulphides. Experiment 2: Hydrogen led in by the positive pole and the gases extracted as above, gave the well-known acetylene compound with ammoniacal subchloride of copper; while, at the same time, a wash-bottle containing water gave distinct evidences of the presence of hydrocyanic acid. Experiment 3: Hydrogen flame burning alone gave no sulphides or hydrocyanic acid, the condensed water in a small bulb gave nitrites. Experiment 4: Air drawn through the negative carbon gave considerable quantities of hydrocyanic acid, which was greatly increased by extracting the gases through the positive carbon. Air was aspirated at the rate of about one litre per minute. Experiment 5: The same carbons used with De Méritens' magneto machine gave no result. Experiment 6: Carbons purified in chlorine and hydrogen gave with De Méritens' nothing; with Siemens' and a draught of air through the negative pole, a small quantity of hydrocyanic acid, but a larger yield when positive used. The gases extracted after the absorption of the hydrocyanic acid contained acetylene. If the carbons are not purified, sulphuretted hydrogen is always found along with other gases. The inference to be drawn from the above experiments is that the high temperature of the positive pole is required to produce the reaction, which is in all probability the result of acetylene reacting with free nitrogen, as when induction sparks are passed through the mixed gases, viz.: $C_2 H_2 + N_2 = 2 H C N$, and that the hydrogen is obtained from the decomposition of aqueous vapour and the combined hydrogen in the carbons. It is possible traces of alkaline salts in the carbon poles may favour the formation of hydrocyanic acid, but, as all attempts to purify the poles so as to stop the reaction failed, I am inclined to believe it is a direct synthesis. The acetylene reaction is one of the many remarkable syntheses discovered by Professor Berthelot, of Paris. The presence of sulphuretted hydrogen is doubtless due to the reduction of the sulphates, invariably present in the ash of the carbon. A more complete examination of the various reactions to be brought about by means of the Siemens arc, and with poles of varied composition, and in presence of different gases, will be communicated to the society in a subsequent paper. My thanks are especially due to Messrs. Ausdell and Cottrell, assistants in the Royal Institution, for their valuable aid.

Gas v. Electricity for Harbour Lighting.—The comparative merits of gas and electricity for the lighting of harbours are now being tried on a rather extensive scale at Havre. Several improved gas-lights and electric lamps have been erected upon the quays of the outer port and upon the north jetty, with the view of testing the suitability and cost of each system, and it will be seen from the following figures, which are quoted from *Le Gaz*, that the advantage is considerably on the side of gas. The electric lamps at present fixed are placed about 33 yards apart, and, supposing this distance to be found suitable, it is estimated that some 60 lamps in all would be required for the lighting of the outer port and jetties. For supplying these lamps, three dynamo-electro machines at least would be required, exclusive of reserve force, which ought to be provided to guard against accident. These machines, with the necessary conductors, commutators, lamp-pillars, &c., are estimated to cost £4,600. The motive power required—say six 18 horse-power steam-engines—would come to £4,800; making a total of £9,400 to be laid out in establishing the service. The cost of maintenance, interest on capital, depreciation-fund, and incidental expenses, would amount to an additional £4,000 per annum. This exceptionally brilliant illumination would be employed on the average for about three hours of the night tide, or, for the year, a total of 65,700 hours. The net cost per hour of each electric lamp would therefore be 1s. 2·6d. Taking gas as the illuminating agent, in order to obtain an equal amount of light to that afforded by the electric lamps, it would be necessary to employ 67 of the improved gas-burners. These burners consist of two concentric rings superposed, and pierced laterally with small holes, somewhat similar to those made in devices used for public illumination. They furnish the light of 190 candles with the consumption of from 56·5 to 60 cubic feet per hour. The annual consumption of gas would be about 4,145,000 cubic feet, which, at 4s. per 1,000, would amount to £828 per annum, or 3d. per lamp per hour. It will thus be seen that the electric light would cost nearly five times as much as gas for an equivalent amount of illumination furnished.—[The above is taken from a contemporary devoted to the interests of gas. We have to point out that here, as throughout the controversy of electricity *v.* gas, the statements are of such an indefinite character that they mean nothing. The use of introductory words such as "say," "would be about," &c., lack everything that is essential to the real discussion of the question.]

The Post Office and the Telegraph Companies.—Mr. Richard Herring, of St. Mary's-road, Canonbury, who has on so many occasions publicly criticised the management of the Post Office, has supplied us with the basis of the distribution of the award of the Government purchase money of the United Kingdom Telegraph Company. It will be remembered that the report of the Treasury, of which we recently published an abstract, stated that these particulars could not be furnished by the Post Office. Mr. Herring has favoured us with the following communication supplied to him in the year 1871: Six per cent. debenture debt fully paid up, not redeemable for 99 years unless at request of holder, to receive principal and bonus of £34 per cent.; 6 per cent. debenture debt not fully paid, redeemable only as above, to receive principal sum paid and bonus of £34 per cent. on nominal amount of bonds, *i.e.*, on sum paid and to be paid; 6 per cent. debentures payable at dates within nine years, fully paid, to receive principal and interest to date to which the bonds run, at 6 per cent., less a discount of $4\frac{1}{2}$ per cent. from date of payment; 1,012 redeemable preference 10 per cent. shares of £5 each to receive principal and bonus of £5 per share; 1,579 6 per cent. preference shares of £5, to receive principal and bonus of £1 6s. per share; 20,000 10 per cent. new preference shares of £5 to receive principal and bonus of £5. The bonus in each case was calculated to compensate for loss on market price on an average of dates. All interest on each class of debenture and preference shares was to be paid to the date at which they were paid off; 27,496 ordinary £5 shares to receive balance of the compensation about £7 15s. per share.

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NIL-TESTING AND DUPLEX TELEGRAPHY IN SUBMARINE CABLES.

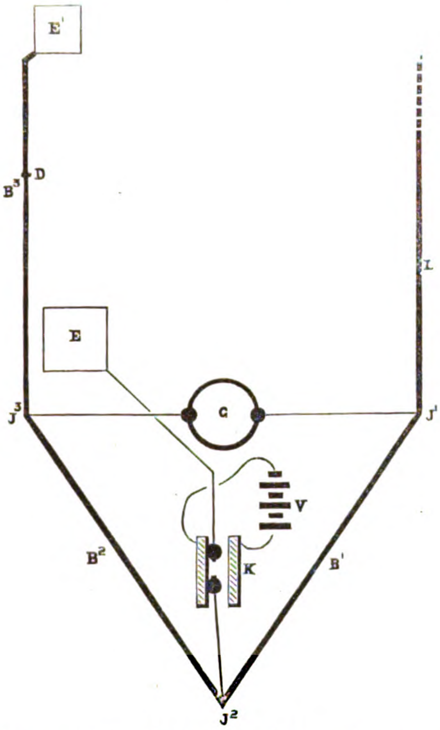
BY SIR WILLIAM THOMSON, LL.D., F.R.S.

Nil-testing, whether by differential galvanometer or Wheatstone's bridge, contains the essence of duplex telegraphy. The want of an earth-connection for the zero in testing laid cables by the nil method, as too commonly practiced, vitiates the result by leaving uneliminated the influence of earth-currents. Thus we often find in the test-book of submarine telegraph stations such entries as

"Copper resistance *positive* 7386
,, ,, *negative* .... 4934,"

the illogicalness of which has led non-scientific telegraphists into error as to practical modes of balancing earth-currents in duplex telegraphy.

The proper arrangement for eliminating earth-currents from the Wheatstone bridge nil test is represented in the annexed sketch.



The steady or varying deflection of the galvanometer G shows the earth-current when the key K (an ordinary Steinheil signalling key) is untouched, as in the sketch. The resistances in the branches B_1, B_2, B_3 must, by changing one or more of them, be adjusted by trial, so as to reduce to *nil* the permanent effect on the strength of the current through G, of pressing either stud of the key, or of ceasing to press one stud and pressing the other. Then, if r_1, r_2, r_3 denote the resistances in the branches B_1, B_2, B_3, and l that of the line, we have $l = \frac{r_1}{r_2} r_3$.

The result is independent of the earth-current, *except so far as it may have changed* in the course of *the time required for the practically complete charging or discharging of the cable after each change of the key*. This "exception" constitutes but a slight drawback from absolute accuracy, and for most practical purposes a single completion of the process as above described suffices. When extremely minute accuracy is desired, the process must be repeated many times, and the simple mean of the results may be taken as the true value of l. The chief practical inconvenience arising from the electrostatic capacity of the cable is the necessity for waiting till the spot of light from the galvanometer settles to its fresh position of equilibrium after the violent shock it experiences at the instant of each change of the key. This inconvenience is much diminished by the use of a proper dead-beat galvanometer instead of the forms commonly supplied by instrument makers. With the dead-beat galvanometer, the process of the gradual charging or discharging of the cable may be deliberately watched during the fraction of a minute within which, even in the longest cable, it is practically completed, and the tester judges readily *when* the fresh equilibrium-position is nearly enough reached for the purpose of his test.

But the greatest perfection of *nil-testing* in submarine cables is attained by the use of the model cable described by Mr. C. F. Varley in two patents, one of date 1858 or 1860 and the other 1862. In the former of these patents he describes the application of condensers to different points along the line of resistance J_3 D E' of the preceding sketch, in an arrangement differing from the preceding only in the use of a differential galvanometer instead of the Wheatstone bridge $J_1 J_2 J_3$. He shows how, by adjusting the resistance B_3 to obtain the nil effect *on the permanent current* after each change of the key, and then applying condensers to a sufficient number of points along the line of resistance J_3 D E', by trial, till it is found that the position of the galvanometer needle is absolutely unchanged by changes of the key, a perfect representation both in respect to resistance and to static capacity of the actual cable (which may have a fault or faults in it) is artificially produced in the branch B_3. This was precisely the arrangement required for duplex telegraphy through the cable, but theoretically the perfect nil-adjustment requires an infinite number of condensers distributed along the branch B_3, with infinitely small differences between them; and many years passed before the instrumental appliances required to give a sufficiently approximate realisation of this condition for practical purposes were produced. A fair approach to practical duplexing was obtained on several sections of the Eastern Company's lines in the summer of 1873, simply by the carrying out of Varley's original plan; but a great improvement was soon after introduced by the application of the *continuous* model cable invented by Messrs. Muirhead, which, by fulfilling the theoretical condition of a perfect representation of the cable thoroughly, in respect to the relation between the resistance of the metal core, and its electrostatic capacity as an insulated conductor, gives a much better practical *nil* effect of sent current on the receiving recorder (put in the place of G in the preceding sketch) than had been obtained by subdivisions of condensers with resistances interposed according to Varley's method.

A NEW THEORY OF TERRESTRIAL MAGNETISM.

BY PROFESSORS JOHN PERRY AND W. E. AYRTON.*

In the autumn of 1876, while experimenting on magnetic transparency, we designed an apparatus for testing whether a moving body having a definite electric charge would, like a current, deflect a magnet. While waiting for the conclusion of the rains, and the advent of the very dry season which accompanies a Japanese winter, in order to try our instrument in conjunction with an ordinary plate-glass electrical machine, we received the account, published in the *Philosophical Magazine* for September, 1876, of the experiments just performed by Mr. Rowland in the laboratory of Professor Helmholtz, by which it had been conclusively shown that a charge of electricity mechanically moved had the properties of an ordinary electric current as far as the deflection of a magnet was concerned.†

Until this point was settled, it was unlikely that attention would be directed to the electro-magnetic effects that might arise from the rotation of a charged body like the earth. Shortly, however, after the execution of the experiments referred to we attempted (as described in our Paper "On Rain Clouds and Atmospheric Electricity," which appeared in the *Philosophical Magazine* for March, 1878) the solution of a new theory of terrestrial magnetism. This problem we have attacked in a variety of ways; and the following solution, to which we have at length been led, we beg to offer for the acceptance of the Physical Society.

The points near the surface of the earth have different linear velocities from those in the interior (although all the points have the same angular velocity of rotation round the earth's axis); therefore, if the earth had an initial electrical charge, residing, of course, in accordance with the well-known electrical law, on its surface, the electrified particles would have velocities relative to the remainder; hence, as a direct consequence of the results of the experiments published by Professor Helmholtz, the interior of the earth would be a magnetic field, quite independently of its interior constitution. And precisely similar reasoning, of course, proves that outside the earth's surface there would also

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* Communicated by the Physical Society, having been read at the meeting on March 8.

† Additional confirmation has recently been given on this subject by the experiments described by Mr. Crookes in his Paper on the "Illumination of the Lines of Molecular Pressure, &c.," since he has shown that the stream of particles which is shot off from the negative terminal in a very pe rfect vacuum, and which produces the green phosphorescence, carries elea ctricity with it and is deflected by a magnet. This may be regarded as a sort of converse experiment, since it proves that a magnet deflects a moving charge of electricity.

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be a magnetic field. (*Vide* addition which appears in the next number of *The Electrican*). To determine the strength of this field we have the following relationship to start with.

In § 526, Clerk Maxwell's "Electricity," it is shown that an element of current C, of length S T, acts upon a unit magnetic pole at a point P with a force $C\frac{ST}{PS^2}\sin PST$, in a direction at right angles to P S and S T. Combining this with the experiments referred to above, we may assume that if a charge of static electricity (measured in electro-magnetic units) Q, at the point S, moves in a direction S T with a velocity v *relative* to a point P, it produces on a unit magnetic pole at P a force $\frac{Qv}{PS^2}\sin PST$ in a direction at right angles to P S and S T; and this is the *only assumption* employed in the following investigation.

Now suppose the earth to have the uniform density of electricity σ over its surface, and let its radius be unity. Consider the force produced, by the rotation of the electricity at a point S on the surface having co-ordinates r, θ, ϕ, at a point inside the the sphere having the co-ordinates r_1, θ_1, ϕ_1. Then if the sphere be rotating with an angular velocity w round the axis of z, and if θ be the angle between this axis and a radius, while ϕ is the angle between the axis of x and the projection of a radius, the velocity of S relative to P will have for its co-ordinates

$$u \text{ or } -w(\sin\theta\sin\phi - r\sin\theta_1\sin\phi_1) \text{ parallel to } x,$$

$$t \text{ or } \quad w(\sin\theta\cos\phi - r\sin\theta_1\cos\phi_1) \text{ parallel to } y;$$

also $\quad PS^2 = l^2 + m^2 + n^2,$

where $\quad l = \sin\theta\cos\phi - r\sin\theta_1\cos\phi_1,$

$$m = \sin\theta\sin\phi - r\sin\theta_1\sin\phi_1,$$

$$n = \cos\theta - r\cos\theta_1.$$

Now, the direction-cosines of P S are proportional to l, m, and n; and the direction-cosines of S T, the direction of motion of S *relatively* to P, are proportional to u, v, or to $-wm$, wl, and 0. Consequently P S is perpendicular to S T. Also, if λ, μ, ν are the direction-cosines of a line at right angles to P S and S T,

$$\lambda = \frac{nl}{PS\sqrt{l^2+m^2}},$$

$$\mu = \frac{mn}{PS\sqrt{l^2+m^2}},$$

$$\nu = \frac{-(m^2+l^2)}{PS\sqrt{l^2+m^2}},$$

where the negative sign must be given to the root. Now, if F is the force at P due to the charge of surface-density σ on the elementary area $d\theta \,.\, \sin\theta \,.\, d\phi$ at S moving relatively to P, we know that it must be at right angles to P S and S T, and equal to

$$\frac{\sigma\sin\theta\,.\,d\theta\,.\,d\phi \times \sin PST\sqrt{u^2+t^2}}{PS^2}.$$

Hence, if δX, δY, δZ be the resolved portions of the force F parallel to the axes of co-ordinates, and if dS stands for $\sin\theta \,.\, d\theta \,.\, d\phi$, we have

$$\delta X = \frac{\sigma\,.\,dS\,.\,\sqrt{u^2+t^2}}{PS^2}\lambda;$$

and similarly for δY, δZ.

Hence, if $\iint$ stands for the summation over the whole surface of the sphere, and if X is the total force at P in the direction of the axis of x,

$$X = -\iint \frac{\sigma\,dS\,w\sqrt{l^2+m^2}}{PS^2}\;\frac{nl}{PS\sqrt{l^2+m^2}}$$

$$= -\iint \frac{\sigma w\,dS}{PS^2}\,n\,\frac{l}{PS}.$$

Similarly,

$$Y = -\iint \frac{\sigma w\,dS}{PS^2}\,n\,\frac{m}{PS},$$

$$Z = \iint \frac{\sigma w\,dS}{PS^2}\;\frac{m^2+l^2}{n}\;\frac{n}{PS}.$$

Now, the resolved part of the force along the axis of x is the same as would be the force in that direction due to a distribution of attracting matter of density $-n\sigma w$ over the surface of the sphere. Similarly, the resolved part of the force along the axis of y is the same as would be the force in that direction due to a distribution of attracting matter of density $-n\sigma w$ over the surface of the sphere; and the force in the direction z is the same as would be the force in the same direction due to a distribution having a density $\sigma w\frac{l^2+m^2}{n}$ or $\sigma w\left(\frac{PS^2}{n} - n\right)$. Regarding the force as being due to such a distribution,

$$Z = \iint \frac{\sigma w\,dS}{PS^2}\cdot\frac{PS^2}{n}\cdot\frac{n}{PS} - \iint \frac{\sigma w n\,dS}{PS^2}\cdot\frac{n}{PS}.$$

Now, the first integral is $\iint\frac{\sigma w\,dS}{PS}$, which we know has a value equal to the potential inside the sphere due to a uniform distribution of density σw over the surface, and is therefore a constant $4\pi\sigma w$. So that the entire force in the direction z is $4\pi\sigma w$ minus the force in direction z due to a distribution of attracting matter of density $n\sigma w$ over the surface of the sphere.

Now, it is easy to show that a distribution of attracting matter of a density proportional to n or to $A + C\cos\theta$ over the surface of a sphere will give

$$X = 0, \quad Y = 0, \quad Z = \text{a constant}.$$

Therefore all that is necessary is to determine the value of this constant. We neglect the term A, because a uniform distribution produces a constant potential, or a zero force in all directions; the distribution $C\cos\theta$ being a zonal harmonic, produces a potential inside the earth

$$V = \frac{4\pi C}{3}r\cos\theta_1 = \frac{4\pi}{3}Cz;$$

so that the force Z which equals $\frac{dV}{dz}$ is $\frac{4\pi}{3}C$. Thus, for the distribution $C\cos\theta$ we have the force $\frac{4\pi}{3}C$; so that the constant force above mentioned, $4\pi\sigma w$, requires the distribution $3\sigma w\cos\theta$. From this we must subtract the distribution $n\sigma w$. or $\sigma w(\cos\theta - r\cos\theta_1)$, giving us for the total distribution of attracting matter over the surface of the sphere a density $2\sigma w\cos\theta + \sigma w r\cos\theta_1$; but the latter term means an uniform distribution, producing, therefore, no internal force, and may, therefore, be neglected. And the first term is a zonal spherical surface harmonic; therefore the electro-magnetic potential due to the rotation of the electricity on the surface of the earth is

$$\frac{4\pi}{3}2\sigma w r\cos\theta_1 \text{ inside the earth,}$$

and $\quad -\frac{4\pi}{3}2\sigma w\frac{1}{r^2}\cos\theta_1$ outside the earth,

where w is the angular velocity of the earth on its axis, r the radial distance of any point from the earth's centre, θ_1 the co-latitude of the place, $4\pi\sigma$ the total quantity of electricity uniformly distributed over the surface of the earth measured electro-magnetically, and the unit of length the earth's radius.

These results, which we think are logical consequences of the experiment performed by Mr. Rowland in Professor Helmholtz's laboratory, and referred to at the commencement of this Paper, may now be applied in various ways.

For example, if the iron of the earth is arranged nearly in a hollow sphere, of external and internal radius a_2 and a_1, then, since the potential given above is a zonal harmonic, we can at once apply Poisson's result; and we find that the potential due to magnetisation of the hollow sphere is

$$-\frac{4\pi\kappa(3+8\pi\kappa)(a^3_2 - a^3_1)\frac{8\pi}{3}\sigma w a^3_2}{9 + 36\pi\kappa + 32\pi^2\kappa^2(a^3_2 - a^3_1)}\;\frac{\cos\theta}{r^2}$$

for all points outside the outer surface of the sphere; and hence, for points outside the surface of the earth, the total magnetic potential is

$$V = \left[\frac{4\pi\kappa(3+8\pi\kappa)(a^3_2 - a^3_1)\frac{8\pi}{3}\sigma w a^3_2}{9 + 36\pi\kappa + 32\pi^2\kappa^2(a^3_2 - a^3_1)} + \frac{8\pi\sigma w}{3}\right]\frac{\cos\theta}{r^2},$$

where κ is the coefficient of magnetisation, and σ now is the density of negative electricity revolving with the earth from west to east.

Now Biot's approximation to the law of intensity of the force is

$$\sqrt{1 + 3\sin^2\lambda},$$

where λ is the latitude of the place; and we understand that this approximation is generally considered, for rough purposes, as a fairly accurate one.

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Our equation for any point at a distance r from the centre, and having a co-latitude θ, is $V = M \frac{\cos\theta}{r^2}$; and

$-\frac{dV}{d\theta}$ is the force directed towards the north,

$-\frac{dV}{dr}$ is the force directed downwards towards the earth's centre.

Therefore, if I be the magnetic intensity,

$$I^2 = \left(\frac{dV}{d\theta}\right)^2 + \left(\frac{dV}{dr}\right)^2 = \frac{M^2 \sin^2\theta}{r^4} + \frac{4M^2\cos^2\theta}{r^6},$$

or, putting r equal to unity (that is, for a point on the earth's surface),

$$I = M\sqrt{1 + 3\cos^2\theta} = M\sqrt{1 + 3\sin^2\lambda},$$

which is Biot's expression.

Now, this is a result which could not have been anticipated, and speaks well for our new theory of terrestrial magnetism.

It is well known that many forms of distribution of iron inside the earth may be found which, with the existing potential given above, will produce Gauss's distribution of potential over the surface of the earth; and it would be very interesting to try how close an approximation to the real potential would be obtained by considering the iron of the earth to form a hollow ellipsoid, one of its principal axes coinciding nearly, but not quite, with the earth's axis. This calculation would be comparatively easy, but we prefer at present merely confining ourselves to *simple illustrations* of our theory.

Thus, let us, for simplicity, assume that the magnetic matter of the earth is iron, with everywhere a coefficient of magnetisation $\kappa = 30$;* then the terms involving κ^2 will be large compared with the others; so that if, for a very rough approximation, we assume a_1 to be nought and a_2 equal to unity, or the whole earth to consist of iron, we find

$$V = \frac{16\pi}{3} \sigma w \frac{\cos\theta}{r^2}.$$

Now, Gauss gives for the magnetic moment of the earth $3{\cdot}3092\ n^3$, in millimetre-milligramme-second units, and where n is the number of centimetres in the earth's radius. Consequently, since the dimensions of a magnetic moment are $M^{\frac{1}{2}} L^{\frac{5}{2}} T^{-1}$, the earth's magnetic moment becomes $\cdot 00033092\ n^{-\frac{5}{2}} n^3$, the units being the earth's radius, gramme, second.

(TO BE CONTINUED.)

THE ELECTRO-MAGNETIC ENGINE OF M. MARCEL DEPREZ.

BY M. DU MONCEL.†

Electro-magnetic motors have for a long time past engaged the attention of inventors and *savants*; and, twenty-five years ago, much money was spent in investigations in this direction. It is difficult to realise what amounts have been absorbed in fruitless attempts which have not advanced the solution of the problem by one step. The journals certainly spoke of electro-magnetic engines having the power of several horses; but their allegations were altogether imaginative; for no motor of this description has even produced a horse-power. We know in fact that the principal electro-magnetic engines which at various periods have been tried at the *Conservatoire des Arts et Métiers*, and which were very bulky, have never supplied more than one and a half *kilogrammètre*, that is about one-quarter of a man-power; and even this force was only obtained by an enormous expenditure. Thus in the case of the Larmengeat engine, the expense of the battery, in zinc alone, amounted to 3f. 15c. per H.P. per hour. In the case of the motor of M. Roux this expense, it is true, was only half the above sum; but for the engines of MM. de Molin and Allen the expenditure of zinc was from 17 to 25 kilogrammes for the same power and time.

I have explained at length, in the fifth volume of my "Exposé des applications de l'Electricité," the obstacles which opposed the success of this kind of apparatus; but the question has recently presented itself under another aspect, and we perceive that the continuous-current magneto-electric machines, such as those of Gramme, Lontin, Siemens &c., may make excellent motors and even transmit the power under relatively good conditions, since they utilise about from 40 to 50 per cent. of the work which theoretically should be performed by the electric generator. M. Mascart has published a very interesting work on this kind of transmission of force, which will be found in the *Journal de Physique* of 1878, and the question was also treated by myself in an article which appeared in *l'Electricité* of Jan. 20, 1879. Still, these systems require very powerful currents in order to work the machines; and it was desirable in many industrial applications to obtain an electro engine of small dimensions and capable of doing useful work. This is the problem which has recently been solved by M. Marcel Deprez by the most simple means. His apparatus is in fact only 20 centimetres (8 inches) in length by 15 centimetres (6 inches) in breadth, it weighs less than 3 kilogrammes (6lb. 10oz.), and can supply a power of 1·1 kilogrammètre (8ft.-lb.) per second with five Bunsen elements. This is really an extraordinary result, and one which could scarcely have been anticipated a few years ago. Under these conditions sewing machines may with perfect ease be worked by electricity without any cumbrous apparatus.

This ingenious system consists of a horse-shoe magnet of eight plates, 14½ centimetres in length, between the poles of which is introduced a Siemens armature, which is acted upon by the magnet over a length of 7 centimetres. Up to the present time no one has ever thought of causing magnets, or electro-magnets to act otherwise than by their polar extremities; and all the engines devised hitherto have been arranged on this principle; but M. Marcel Deprez, thinking that under these conditions the whole of the magnetism that can produce a magnetic organ was not utilised, endeavoured to cause the whole of the sufficiently-magnetised portions of the magnetic organ to act upon the mobile system to be influenced; that is to say, in the present case, the branches of the magnet nearly up to the neutral line. The electro-magnetic armature, instead of being placed transversely to the magnet, is arranged longitudinally and parallel to it. Under these conditions the magnetic power exerted on the armature is found to be considerably augmented, as is perceptible from the difficulty experienced in producing rotation; and this increase of force may give an idea of the considerable advantages presented by this system of motor, which works by the effect of successive reversals of the current.

Everybody knows the Siemens armature; it is a kind of galvanometer frame, of which two sides constitute the two poles of a straight electro-magnet with a flat core, broader than it is long, upon which the wire is wound. The axis of this electro-magnet is parallel to the coils of wire in the magnetising helix, and, consequently, to the arms of the magnet. At one end it carries a reversing commutator, and at the other end it is provided with a pinion which gears into a wheel of which the diameter is 30 times greater. When the apparatus is properly regulated, the armature makes 90 revolutions per second; and, consequently, the wheel which it acts upon makes three revolutions. It is upon the axis of this wheel that are fixed the pulleys transmitting the movement, and by which the engine is caused to work either a sowing machine or any other apparatus which is to be set in movement.

In order to render the working of this apparatus perfectly uniform, M. Marcel Deprez has adapted to it an extremely ingenious regulator, the action of which is very efficacious; it is a sort of spring fixed by one of its extremities to one of the ends of the armature. By means of a screw, a tension suitable for any given velocity of the engine is given to the spring. The transmission of the current from the commutator to the wire of the armature is effected without difficulty by this spring, as in the case of all frictional contacts; but, when the velocity is greater than that which is requisite, centrifugal force is brought into action, and the mass of the spring causes it to fly off and to break the circuit, whence results a slackening of the speed, and then the completion of the circuit, which is again broken when the velocity again becomes too great. These alternations are so rapid when the electric power is somewhat higher than is strictly necessary, that a continuous spark is seen at the commutator where the regulating spring is in contact with it.

As will be seen, nothing can be simpler than this little apparatus, which, as at present constructed, may be of great service. Its force may be estimated by trying to stop the pulley of which the diameter is 10 centimetres. With the five Bunsen elements which have been mentioned, this stoppage can be effected only with great difficulty; whereas with the ordinary electro-magnetic engines it is easy to produce a stoppage by pressing a little upon the axis of rotation.

---

* κ for ordinary iron is probably between 20 and 30; and in our ignorance of the internal state of the earth, or what effect the great heat or pressure may have on the coefficient of magnetisation, we are compelled to use this value; but it is possible, of course, that the real value of κ may be very different.

† Translated from *La Lumière Electrique*.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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THE COMPANIES AND MERCHANTS.

The results of competition are not always satisfactory to the competitor. It is therefore thought convenient sometimes, in the struggle for existence, to ignore the claims of a neighbour and to look upon one's own success as the sole aim in life. The fear that somebody will do something not altogether advantageous to our interests frequently causes trouble to be met far more than half way. We consider this is the case with the merchants who present the memorial given in another column. They put forward an array of statements which, so long as they are uncontradicted, lead one to suppose that their grievances must weigh heavily on their shoulders. Before again giving the answers to these statements which are altogether ignored, it may be as well briefly to glance at the situation. The questions under discussion relate more especially to the Submarine Cable Companies. Mr. J. Pender, M.P., speaking at the dinner to the Delegates of the International Congress, held at the Freemasons' Tavern on June 18th, stated that the submarine cables were practically the outcome of fifteen years work. There is no doubt that the commencement of cable work indicated a new departure in the world's history. It was a unique experiment. It has succeeded. The rules and regulations necessary for the guidance of cable traffic could not be predicted *a priori*, but were of necessity the result of experience. The early regulations were merely tentative, and as traffic developed had to undergo elisions and additions. The companies have their claims, and we maintain these are as worthy of consideration as those of the merchants. To embark in cable work fifteen years ago was looked upon as embarking in an undertaking of a somewhat speculative nature. We know now that the cables then laid were far from perfect, dangers then unknown could not be provided against, and hence the risk of failure was very great. It has always been put forth as an axiom that great risks ought to give corresponding great returns. This has never been the case in cable work. The returns have not been great, and had it not been for the care exercised in the management and administration of the lines the results would have been disastrous. There is hardly another branch of enterprise—even if there exists one other—that can boast of such concentrated talent devoted to its development. Cable enterprise has combined the highest scientific and the highest commercial talent, the results of which combination we see in the expansion and the conduction of the lines of to-day.

The regulations formulated in the early days of cable work have from time to time been amended, and the unbiassed onlooker will say that the alterations have not been, on the whole, in favour of the companies, but rather in the interests of commerce. What, then, do the merchants ask for? A partial return to the tentative regulations of eight years ago, and an extension of the rules, which, if allowed, would go far towards the ruin of the companies. Let us consider the memorial from the end. A fear is implied that some change will be made as to code and non-code messages. There has been, and there is, no distinction in the tariffs between code and non-code telegrams, but the companies do justly complain of a hardship which requires mitigation. They do not complain of codes as codes; in fact, it should be placed on record that the companies were the first to introduce codes, these codes, of course, consisting of words suitable for telegraphy, and, so far as we can gather, answering every requirement of the merchant. They now complain of the tendency of code compilers to introduce hybrid words, words unknown in use, and which sin against every law of grammatical construction. For the sake of economy, the merchants adopted methods by which a word stands for a sentence and a sentence for a pamphlet, where every suffix and affix means a phrase, and every syllable, in fact, has its special meaning. The ingenuity of compilers has been exercised in putting prefixes from one language to the stem of another, and adding an affix from a third. The complaint of the companies is that the use of words so formed causes extra labour, leads to mistakes in transmission and necessitates repetitions, blocking the lines and keeping back messages, which means, of course, a loss of money. In *The Electrician* of May 25, 1878, Sir James Anderson formulated the requisites of a telegraph. It must be reliable, accurate, and speedy. He dealt fully and ably with the subject, and, till his arguments have been controverted, we must hold that they are unanswerable. The Paper referred to considers the question of word-combination with the result of advocating the restriction of languages to

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six. It will be seen that the memorialists admit that French, German, English, Dutch, Spanish, Italian, Latin, Greek, and Turkish are the languages principally used, but they advocate the admission "of any known language." A correspondent in our issue of last week (*see* p. 59) says: "I maintain that the telegraph companies are in duty bound to protect their servants from the largely-increased labour long code words bring." A cynic might reply with some justification that this was hardly a servants' question. Whilst, however, quite concurring with the writer, we would go further and say the companies are in duty bound to protect themselves. If the use of these words causes needless mistakes and repetitions, we hold that the sender must suffer the loss. The companies are not founded to solve conundrums, nor is an operator supposed to send such words as "Ghafdjdaki," "Hamzyzmich," as quickly as he can such well-known words as "Constitute," "Noticeable," &c. A glance gives him the one, and his work is partially mechanical; his attention must be constant on the other, and a greater mental strain results. He works less speedily, and his energies are diminished more rapidly, the company losing on both sides.

We stated last week that, so far as we can gather, no company has entertained the idea of advocating a less limit than the ten-letter limit per word, and we should think that one and all would oppose the increase of the limit to twelve letters. As some of our correspondents have noticed, it is almost always possible to use a short word instead of a long one. The advocacy, though ostensibly for such words as "unreasonable," "subscription," &c., is really this—that the extension from ten to twelve letters permits the adding of another affix and the signification of another phrase or sentence. No doubt it would practically be of more value to the public if the companies would generously open their lines and send messages in any language and of any length for nothing. The shareholders would, perhaps, object to this, and, if the public consider only one side of the question, it is necessary that some one should consider also the other side.

"We are often told that telegraph officials only see the question from their own side, and that merchants are convinced they will use the telegraph much more than we imagine if greater *facilities* are given. But all experience, ever since the telegraph was established, has demonstrated that every *facility* has been at the expense of revenue."* Such a statement as this makes it plain that a perfect reconciliation of the interests of merchants and companies must be sought in a *via media*, and that the companies have certain claims that cannot be ignored.

* Sir J. Anderson. Vol. I., p. 19.

CORRESPONDENCE.

DUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. John Muirhead, jun., has in his letter to you of the 18th inst., taken the most unusual course of sending you for publication a copy of his solicitors' letter without giving you my solicitors' reply. I am, therefore, under the necessity of asking you to print the annexed reply which they sent.

With regard to Mr. Muirhead's assertions on the subject of infringements of my patents, I think that question had better be left for the decision of the proper tribunals in all the countries where I have patent rights.

I regret to be obliged to address you again, as it is extremely undesirable that important subjects, likely to come before the courts, should be discussed in a public journal; and I trust there will be no further necessity for printing correspondence which clearly should only be used when the case is brought before the courts.—Yours, &c.,

London, 23rd June, 1879. J. B. STEARNS.

(COPY.)

1, Copthall-buildings, E.C., London, 8th May, 1878.

STEARNS AND MUIRHEAD.

DEAR SIRS: As your letter informed us that Messrs. Muirhead had actually supplied the Direct U.S. Cable Co. with their apparatus, we wrote to the Company's solicitors for an explanation, as we held their undertaking to pause before taking any steps.

They say that your clients have only been allowed to make "experiments" with the cable.

Though we think, under the circumstances, this is hardly such a compliance with the undertaking as Mr. Stearns was entitled to expect, we have not made a formal complaint, but have written, suggesting that they had better give us an admission (which we asked for some time ago), and we will then at once take proceedings here, and in the United States and Canada.

Surely we need scarcely point out to you that this is peculiarly a case in which the user must be sued, and Mr. Stearns must be allowed to exercise his discretion in engaging in litigation which must necessarily be of a heavy character.—We are, dear sirs, yours truly,

(Signed) WILSON, BRISTOWS, AND CARPMAEL.

Messrs. Bircham and Co., 60, Threadneedle-street, E.C.

INTERNATIONAL TELEGRAPH CONFERENCE. DINNER AT RICHMOND.

The members of this Conference on Saturday last made an excursion, and, after visiting Hampton Court, were conveyed in carriages to Kew Gardens. At the conclusion of a brief stay at the latter place, they proceeded to Richmond, and the whole party dined together at the far-famed hostelrie the Star and Garter, at the invitation of the Joint Reception Committee of the Post Office and the Telegraph Companies. The whole of the Delegates to the Conference personally responded to the invitation, with the exception of Herr Scheffler, who was unfortunately prevented by indisposition from attending. The chair was taken by Colonel Holland (Chairman of the Indo-European Telegraph Company, and of Reuter's); and Mr. W. H. Preece, Colonel Champain, Captain Mayne, Mr. Fischer, Captain Anderson, Mr. Patey, and Mr. Andrews each presided at a table. There were many ladies present, and amongst those who sat down to the banquet were His Excellency General de Lüders, Count and Countess Reichenbach, Count von Wimpffen, M. Devez (Post-master-General of Austria), Herr Budde, M., Madam, and Mdlle. Vinchent, Signor D'Amico, M. Do Rego, Dr. Brunner von Wattenwyl, M. von Koller, M. Yoshikama Akimasa, M. Gibbs, Mr. Grichen, Mr. Weaver, Sir Charles Bright, General Tremenheere, Sir Wm. and Lady Baynes, Mr. Erichsen, Mr. FitzGerald, Mr. Ansell, Mr. Pender, M.P.; Mr. Cecil Forrester, M.P.; Mr. Dodds, M.P.; Stefanaki Bey, Major Wood, Mr. T. Fuller, Mr. Alan Chambre, M. Staring, M. Richard, &c.

At the conclusion of the banquet,

Colonel HOLLAND proposed "The Health of Her Gracious Majesty the Queen." A technical difficulty, he said, somewhat interfered with his full enjoyment in proposing this toast. They had been called upon by the toastmaster as "My lords, ladies, and gentlemen." He had an Englishman's respect for Lords and gentlemen, but—

He could not love a Lord so much loved he not Ladies more—

[laughter], and therefore, seeing that this was a toast in honour of the illustrious lady the Queen of this country, he would venture to address them as "My ladies, lords, and gentlemen." During the forty years it had been their good fortune to have Queen Victoria as their sovereign, this toast had always been drunk with enthusiasm by Englishmen and respect by many foreigners [cheers]. He would not pretend to "gild refined gold or to paint the lily," but this toast was in honour of her who was an honour to her sex [cheers], and who represented all that was good in constitutional government. He would conclude by asking their foreign guests to drink to the long life and prosperity of our good Queen Victoria [cheers].

The toast was drunk with enthusiasm.

The CHAIRMAN then gave the toast of the evening, and said: My Ladies, Lords, and Gentlemen: It is my pleasing duty to propose a toast which, I am sure, beforehand, will be received with the applause that its nature merits—namely, "The Health of the Foreign Delegates of the Goverments at the International Telegraph Conference." This toast deserves the applause that

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greets it, because these gentlemen have not only rendered eminent services to their own Governments and peoples, but they have similarly bestowed incalculable advantages upon the mercantile classes engaged in conducting the commerce of the world, and upon the Governments in the important political relations conducted through the medium of the electric telegraph. Nothing has surprised me more than to hear it asked, "What is the good of these international telegraph conferences?" and, startling as it may appear, numbers are ignorant of what we owe to international telegraph convention, and conceive only an ignorant impatience of their rules and regulations. Well, gentlemen, I have replied that without the intelligent and well directed labours of our foreign friends international telegraphy would have been, and must have remained, in great part a chaos. It must be remembered that the telegraph was national before it became international. That each country had its own system, its own scale of charges, its own rules and regulations, admirable enough as applied to the internal relations of its own people, but not adapted for, and not applied to, universal telegraphy. The network of the telegraph, ever extending, connecting up the frontiers, embracing all countries, found its use trammelled and confined by a variety and multiplicity of obstacles to its free development. Neighbouring States formed groups under arrangements for simplifying and facilitating the exchange of telegrams between their populations. But the trammels were still too great, the boundaries were too restricted, and the ever-augmenting demand for freer intercourse called the International Telegraph Conference into being. Eventually new rules, regulations and tariffs, embracing the whole of Europe and the far East, were discussed, and successfully framed and introduced. Apparatus of high speed was adopted, enabling States to converse directly with one another, a system of great international lines of wire was created and successfully established, and the thoughts of men were instantaneously flashed from capital to capital, and across distant lands, in almost the same moment of time that they could find written expression. Gentlemen, this is what the International Telegraph Conferences have done! They have given the Governments and the mercantile classes those direct and rapid means of communication under one, simple, uniform scale of regulations, without which international telegraphy would have remained in the swaddling clothes of comparative infancy, and without which the present magnificent system of direct communication must have continued a dream. I say magnificent, because, familiar as most of us may be with the feats of the telegraph, it is none the less a source of wonder and admiration that intercommunication is now an affair of minutes between London and Berlin, Brussels, Paris, Rome, Vienna, St. Petersburg, and the other great capitals and cities of Europe; and, again, between those capitals and the cities across the broad Continent; whilst even with the most distant parts of India messages are exchanged in from 30 minutes to one or two hours. Gentlemen, are we not apt to underrate, and do we not as a fact underrate the wide-spreading portent of such great facts as these undoubtedly are—marvellous alike in conception and execution; and do we not think too little of the fact that a message, owing to the arrangements so admirably thought out and so skilfully conceived, traverses without hindrance or difficulty thousands of miles of territory safely to its destination? The patient, untiring, and intelligent labours of our friends the foreign delegates to this international gathering have been directed to these great ends; the companies have not unworthily aided in the fruitful work, they too have joined distant parts of the world with one another, and have assisted and acted in concert in developing the unity of this all pervading intercourse. Let me conclude by saying how happy we are to have these distinguished gentlemen in our midst to-night and to give them a hearty British welcome. My ladies, lords, and gentlemen—I give you "The health of the foreign Delegates to the International Telegraph Conference of London," with all the honours, coupled with the name of M. Vinchent, the able delegate for Belgium.

The CHAIRMAN, again rising, said: It was not my intention to rise again, but it occurs to me that we should drink "The Health of the President of the Conference" [cheers]. The Postmaster-General has appointed Mr. Patey, and in appointing that gentleman he has given the Conference one of the ablest men which the Post Office or that England could produce as far as telegraphy is concerned [loud cheers]. In the course of my official duties I have a great deal to do with Mr. Patey, and I have always found him to be a man thoroughly acquainted with his business. I ask you to drink "The Health of Mr. Patey, the President of this Conference" [cheers]. Before Mr. Patey replies to this toast, I will ask Mr. Vinchent, the hon. delegate of Belgium, to respond to the previous toast.

M. VINCHENT, who spoke in French, gracefully acknowledged the distinguished services of English electricians, and rendered homage to England as the initiator or the mother of telegraphy, while at the same he admitted the debt of gratitude they also owed to America for the part the Americans had taken with regard to the development of marine telegraphy. Referring to the proverbial hospitality of the English, he observed that England always afforded an asylum to all who were proscribed [laughter], not that they were proscribed [renewed laughter], but they were, at any rate, in a position to appreciate this broad hospitality which welcomed all who came and which tolerated all opinions [cheers]. He, as the delegate from Belgium, had a special reason to speak with respect of England, for Great Britain had exerted its influence for the protection of his own country, and had shown the world a bright example of progress and freedom. May God protect England wherever she carries her power and her civilisation, and he would conclude with the sentiment of "Old England for ever" [loud cheers].

Mr. PATEY said: I thank you for the cordial manner in which you have drunk my health. I accepted the post of President of the Conference with very great diffidence, especially as I saw around me gentlemen of much greater experience, while I had never been president before. I feel that there have been many shortcomings on my part which I hope you will overlook. I have done my best, but I am afraid it is poorly done [no, no, and cheers]. London and the commercial world at large are much interested in our work, and although we have not yet arrived at any definite conclusion, we hope that on Tuesday something will have been done which will be satisfactory to the Conference [cheers]. The end and aim of these conferences is to do as much as possible for the public benefit, and not at the public expense, while, at the same time, we secure for the telegraph companies or our respective governments a proper return for the work we do [cheers]. Without telegraphy it would now be impossible to carry on many businesses, of which we in England are the chief promoters, and in our work we endeavour to do what is good for the public, and also for the shareholders [cheers].

Count VON WIMPFFEN, speaking in English said: I feel happy to be allowed to add a few words to what has passed here this evening, and I will propose the toast of "The Ladies" [cheers]. The ladies have to-day, in spite of the unfavourable weather [hear, hear], been pleased to accompany us, and to contribute by their presence to the enjoyment of our pleasant meeting to-day [cheers].

The toast having been duly honoured, the company shortly afterwards broke up.

SILVERTOWN WORKS.

The directors of the India Rubba, Gutta Percha, and Telegraph Works Company at Silvertown invited the Delegates of the International Telegraph Conference and a distinguished party of gentlemen interested in telegraphy to inspect their extensive and interesting factories at Silvertown on the 19th inst.

Amongst the delegates and others who responded to the invitation were Commander D'Amico, General de Lüders, Admiral the Hon. Sir H. Keppell, G.C.B.; General Browne, C.B., R.E.; Colonel Crossman, R.E.; Colonel Bateman-Champain, R.E., Pres. S.Tel.E.; M. Budde, M. Honcke, M. Richard, M. Yoshikama-Akimasa, Sir William Thomson, F.R.S.; Sir Samuel Canning, Mr. Baines, Captain Bucknill, R.E.; M. Guildano Effendi, M. Curchod, Captain Suenson, Danish R.N.; Mr. Erichsen, Mr. H. Rawson, Mr. H. Weaver, Mr. Graves, Mr. W. H. Preece, Mr. C. F. Varley, Professor W. G. Adams, F.R.S.; Mr. Chandler Roberts, F.R.S.; Mr. C. V. Walker, F.R.S.; Mr. Ford, Captain Mayne, C.B., R.N.; Colonel Grant, C.B.; Mr. Stearns, M. Niaudet, Colonel Malcolm, R.E.; Mr. R. Sabine, Mr. E. A. Cowper; in short, we may say that, looking over the list of those who accepted the Company's invitation, we miss but few names of those eminent in the branches of applied electricity.

The journey to Silvertown was by water, the Alexandra being engaged for the occasion.

A neat little guide book was supplied to each traveller, so that the principal objects of interest *en route* could be easily recognised. This contained also a compact account of the more important operations carried on at the works, and which were considered of special interest to the party.

The first thing inspected was the operation of cutting, washing, and preparing the gutta percha for insulating purposes. The covering of the copper conductor was next inspected through all the stages of successive coatings to the completed core for the Marseilles-Algiers and other cables, which the company have in hand.

This attracted more than ordinary attention, and the deep

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interest which this part of the work created was sufficient to show that it contained attractions even for our own veteran electricians.

From this part of the factory the party sallied out in small bodies to visit what was more particularly of individual interest—the telephone and instrument making shops, the fire signal arrangement of Mr. E. B. Bright, the battery shops, and torpedo department, which were all inspected with much evidence of interest.

The cable-making machinery became a special object of attraction, where the new Marseilles-Algiers cable is being manufactured for the French Government, as well as the Caspian Sea cable.

From here the testing rooms were visited, and the method of testing fully explained. In this department 100 miles of india rubber core was being manufactured for torpedo cables.

The torpedo shop was illuminated with the electric light, the Serrin, Suisse, Rapieff, and Silvertown lamps being used, the generator being the Gramme machine. In this department a complete set of torpedo arrangements for harbour defence was exhibited, the electrical firing of torpedoes was explained, as well as the testing of submerged torpedoes. Specimens of torpedo cables, fuses, moorings for torpedoes, and firing batteries were also exhibited.

The visitors were then taken through the engineers' shops to the luncheon room, where a very elegant *déjeûner* was laid. At the close of this agreeable break in the programme, the chairman of the company, Mr. Henderson, proposed the health of the Queen, which being duly honoured, "The Sovereigns and Presidents of those States represented at the Conference and the United States" was proposed by the chairman.

The CHAIRMAN then gave "The Health of the Delegates." He said he was much pleased to see them at Silvertown, and hoped that, as the time at their disposal was short, and much remained to be seen, they would excuse him from taking up too much time in making a long speech. He would couple with this toast the name of M. Richard, the French delegate.

M. RICHARD, who replied in French, said that he felt very much honoured in having his name associated with this toast and in the presence of such a distinguished company. On the part of the delegates and himself he might say that they were highly pleased with what they had seen. They fully appreciated the kindness and hospitality of the Silvertown Company, and before taking his seat he would propose, on the part of the delegates, "The Health of the Chairman, Directors, and Administrators of the Silvertown Company," and with this he would beg to propose the name of Mr. Gray, the manager of the company [cheers].

Mr. GRAY, in replying, said that he felt very much pleased at the manner in which his name had been received in connection with this toast. He hoped that the delegates and those gentlemen who had favoured the company with their presence had seen sufficient to convince them that the progress of telegraphy was well represented in the manufacturing process they had seen, and that the varied applications of electricity which they had witnessed would satisfy the delegates and those gentlemen who had to issue orders for cables that there were facilities at Silvertown for manufacturing cables and other telegraph appliances which were unsurpassed in the world, and he hoped that if any gentleman present found the time of inspection too short, an opportunity may be afforded for revisiting portions of the works at a future time [cheers].

The preparation of india rubber for insulating and other mechanical purposes was then inspected. The washing and cleansing shops, masticating, grinding and mixing, callendering sheets, waterproofing and vulcanising shops admitted only of a short visit.

The manufacture of tubing, mats, packing, valves and stoppers were shown. The treatment of ebonite for articles of general use attracted a great deal of interest from the fact that this company enjoys a world-wide renown for the production of ebonite goods.

On the whole, it is impossible to imagine a single factory capable of affording more mental delectation than can be found at Silvertown, and on this account we cannot help congratulating the delegates on the useful, interesting, and hospitable entertainment which the directors of the Silvertown Company provided for them.

The visitors, on joining the Alexandra for the return journey, were saluted with some well-designed torpedo explosions, which were very effective. A disc of gun cotton suspended in mid air was first fired to show the detonation of this substance, and to call attention to the spot where a submerged torpedo was laid. A flag was slowly hoisted as a signal for firing this torpedo, which contained 100lb. of gunpowder. The effect of the explosion was well seen by the spectators on board. An enormous volume of water was thrown up, and fell in spray for a distance of nearly 400 yards.

It may be interesting to those who witnessed this experiment to know that, as the tide had been falling some time, the head of water over the torpedo was reduced about 3 feet; it can, therefore, be easily conceived that a much grander effect would have been produced had it been fired about half an hour earlier.

Favourable weather added considerably to the enjoyments of the excursion to and from the company's works.

INTERNATIONAL TELEGRAPH CONFERENCE.

The following is a copy of a memorial addressed by the Glasgow Chamber of Commerce to the Postmaster-General, under date June 3:—

"In view of the approaching International Telegraph Conference, about to be held in London, your memorialists beg respectfully to bring under the notice of your lordship the question of extra European telegrams. It is believed that the whole mercantile community interested in the trade of the East are most desirous that no further alterations of a restrictive character should be made in the Convention Rules, as such alterations lead to great annoyance, trouble, and expense.

"In order to show the present position of the regulations, your memorialists may be permitted to contrast the rules laid down by the Conference held at Rome in 1871, which were in operation till 1875, with the rules now in force under the St. Petersburg Conference of that year.

"The rules of the Rome Conference of 1871 were considered fair and convenient to all parties concerned. They were as follows:—

"A. The length of the word for a single tariff was fixed at seven syllables.

"B. Any of the languages used in the contracting States or Latin might be employed, as well as all word-combinations not contrary to the usage of the language to which they belonged.

"C. Groups of figures not exceeding five were counted as one word.

"D. Groups of letters not exceeding five were also counted as one word.

"E. The tariff to India was fixed at 4s. per word, and to other places in proportion. But messages containing fewer than ten words were charged as for ten words.

"By the St. Petersburg Conference of 1875, the rules of which are now in force, alterations were made on the Rome Convention, all in a restrictive direction; and this was not accompanied by a decrease in tariff, but, on the contrary, by an increase of no less than 12½ per cent., the rate being fixed at 4s. 6d. per word, instead of the previous rate of 4s. The following explanations will show the restrictive character of the alterations:—

"A. The length of the word, for a single tariff, was shortened to 10 letters. Previously 'unconstitutionally' could be telegraphed as one word; now such words as 'constitute' are the longest that can be sent at a single tariff. Useful and common words—such as 'acknowledge,' 'understanding,' 'inferiority,' 'recoverable,' 'superintend,' 'superfluous,' 'subscription,' &c., or such names of places as 'Southampton,' 'Pondicherry,' 'Argyleshire,' or such proper names as 'Beaconsfield,' 'Camperdown,' 'Chamberlain,' &c.—are charged as two words.

"B. No alteration was made in the rules as to languages and combinations.

"C. Five-figure groups, as before, were admitted at a single tariff, but it was enacted that their presence in a telegram would subject the whole message to compulsory repetition, which adds 50 per cent. to its cost.

"D. Five-letter groups were disallowed.

"E. A single-word tariff was agreed to, instead of the 10-word tariff of the Rome Convention; but this was practically of no benefit to the public, as all short messages under the 10-word tariff were sent through Reuter's agency.

"The above very sweeping changes, as well as the increase of the tariff, were all made in the supposed interest of the telegraph companies, as tending to increase the cost of telegraphing.

"Your memorialists beg to point out that it is impolitic on the part of the telegraph companies, in their own as well as the public interest, to place undue restriction on the words that may be used, because it is only by the freest use of all legitimate ciphers that, with the present high tariff, certain classes of business can be brought within the compass of telegraphing. If the cost of telegraphing exceeds a certain percentage on the value represented by the transactions, the business must be done by letter and not by wire, and telegraphing then becomes the exception and not the rule. Looking also to the perfection, rapidity, and accuracy to which the instruments employed have been brought, and to the very high tariff per word, it does seem unreasonable

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that the telegraph officials should seek to place increased restrictions on the words that may be used in telegrams.

"The merchants in the Eastern and other distant trades have now for some time, at a great deal of expense and trouble, adapted their telegraphing arrangements to the St. Petersburg Rules, and it will be felt to be a matter of very great hardship and unnecessary annoyance if any further alterations in a restrictive direction are made at the conference about to be held. The views of the chamber generally on the different points may be stated as follows:—

"A. Length of the word.—The 10-letter limit is the very lowest which, in the judgment of this chamber, should be fixed, although a limit of 12 letters would lead to less annoyance and be practically of more value to the public. It does not seem unreasonable that such as word as 'unreasonable' or 'subscription' should only pay a single tariff.

"B. Languages that may be used.—The Indian officials have recently given to the Calcutta merchants a list of languages which they state 'under the St. Petersburg Convention are admissible in foreign countries':—

"'French, Norweigan, German, Slavonian, English, Greek, Polish, Swedish, Bohemian, Dutch, Portuguese, Armenian, Croatian, Hungarian, Roumanian, Hebrew, Danish, Illyrian, Ruthenian, Turkish, Spanish, Italian, Russian, Flemish, Latin, and Servian.'

"Of the languages thus sanctioned, those which have been mainly utilised by the Eastern merchants for telegraphing are:—

"'French, German, English, Dutch, Spanish, Italian, Latin, Greek, and Turkish.'

"The present rule is that 'messages may be sent in any of the languages used in the contracting States or in Latin,' but that each Government fixes the language of its own dominions which may be employed. This has led to the anomaly that at present the Turkish Government has allowed Turkish and Armenian, whereas the Indian Government has refused to allow Hindustani to be employed in international messages. Instead of limiting further the languages which may be used, your memorialists trust that no objection will be made to the use, in telegraphy, of any known language.

"C. Word-combinations.—Last year a difference between the Eastern merchants and the telegraph officials occurred as to the construction of the following rule:—'Combinations of words contrary to the usage of the language are not admitted,' the telegraph officials insisting that it excluded all such compound words as were not found in the usual dictionaries and gazetteers, and that it did not admit such combinations as, however correct philologically, were not in actual use. Should this narrow interpretation of the rule be maintained it would give all the more force to the suggestions in the preceding paragraphs, A and B, that the limit of the word should be extended to 12 letters, and that all languages may be used.

"D. Code and non-code words.—Your memorialists have also to express their earnest hope that the present practice, which makes no distinction in the tariff between code and non-code words, will not be disturbed. In no way is it possible for telegraph officials to distinguish between code and non-code words. They can only rely on the declaration of the sender. To fix a higher tariff for code than for non-code words would, therefore, give the unscrupulous sender a very great advantage over those who would not make a false declaration.

"Your memorialists respectfully request your favourable consideration of their representations, and that further restrictions may not be made so that the mercantile community may be saved the annoyance and expense in the alteration of their telegraphing arrangements similar to what they experienced when the present St. Petersburg Rules came into force."

THE CONVERSAZIONE OF THE SOCIETY OF TELEGRAPH ENGINEERS.

The *conversazione* of the society of telegraph engineers was in every way a success, and the collection of instruments and appliances brought together does credit to our instrument makers and contractors as well as to those who organised the whole meeting. It would perhaps have been better, however, for the display of these if they had not been in rooms where they were more or less mixed with the instruments of the permanent exhibition, as the short period for inspection was still further curtailed by the attention being attracted to exhibits which could be inspected at some other time. The very nature of the instruments, too, makes it very doubtful whether there is much to be gained by the very cursory inspection of them which can be given at such exhibitions. If we look at a box of resistance coils, the eye may be pleased with the workmanship and brightness of the brass work, but the accuracy of the instrument has very little to do with this, and may be anything. On the other hand, speaking instruments of a novel and complicated nature cannot easily be mastered by anyone not properly familiar with them without devoting much more time to them than can be spared by anyone endeavouring to see all that is to be seen at these exhibitions. However, these meetings are as much for the purpose that gives them their name as for the inspection of the exhibits; and we must not expect to have seen everything and understood everything when we leave, but be content to have had a pleasant evening, seen some old friends, and learnt or seen at least something new.

Amongst the principal exhibitors were, of course, the Post Office, who exhibited a long list of instruments connected up for working, including the instruments for duplex automatic working.

The India Rubber, Gutta Percha, and Telegraph Works Company exhibited articles from their various departments, including cases of artificial cables equivalent to 1,200 nautical miles of cable of 107lb. copper, 140lb. of gutta percha per nautical mile. These are arranged in cases standing upright like a tall shallow cupboard. They exhibited also, besides all kinds of speaking and testing instruments, several instruments used in torpedo work.

Messrs. Elliott Brothers had a very beautiful collection of their resistance coils, &c.

Messrs. Clark, Muirhead, and Co., showed a Thomson recorder belonging to the Eastern Telegraph Company in duplex work, on Muirhead and Taylor's patents, through 800 nautical miles of Muirhead's inductive resistance, with an Allan relay working a Morse at the other end, also resistance slides, half unit Rheostat for duplex working, galvanometer with opening coils, and standard condensers made with mica, coated with shellac purified with absolute alcohol. Mr. L. Clark exhibited some of his rare old books on electricity, and the catalogue of his valuable electrical library which has been compiled by Mr. Frost.

The Telegraph Construction Company exhibited samples of core of various cables from 1866 to the Natal cable now being laid, also a globe of gutta percha containing water, showing the purity of the material used.

Sir W. Thomson showed his patent marine compass.

Messrs. Theiler and Son exhibited a patent submarine recorder, having an ink syphon pen something similar to Sir W. Thomson's.

Messrs. Siemens exhibited several electrical lamps, field telegraphs, testing apparatus, instruments for speaking, &c.

Mr. Brotherhood showed one of his excellent three-cylinder engines, fitted to two of Siemens' dynamo-electric machines. The current from one of Siemens' machines in the engine-room of the Albert Hall was led to one of those machines, and the Albert Hall pumping engine was, through the Siemens machines, driving the Brotherhood engine at some 300 revolutions backwards, causing it to act as a kind of air pump.

There were numerous other exhibitors of instruments for testing and railway signalling, some telephones, and the phonograph; also Professor Hughes' induction balance, exhibited by Mr. W. Groves, but the noise in the room was too great for us to try this interesting instrument. A specimen of cable broken by an earthquake off the coast of Peru was exhibited by the West Coast of America Telegraph Company, and an interesting specimen of Morse printing through the first Atlantic Cable of 1858 was shown by Mr. Gerhardi. Altogether, the delegates of the International Conference were, we trust, pleased with the *conversazione* which, under the presidency of Lieut.-Colonel Bateman Champain, R.E., had been almost specially organised for the purpose of helping towards their welcome in this country.

To the president and council, and particularly to the secretary, Mr. F. H. Webb, as well as to the various exhibitors, is due the success of the evening, which naturally entailed considerable organisation and careful arrangement.

LITERATURE.

The Telephone, the Microphone, and the Phonograph. By Count Th. du Moncel. C. Kegan Paul and Co.

Le Téléphone, le Microphone, et le Phonographe. Par Le Comte Th. du Moncel. Hachette et Cie.

[SECOND NOTICE.]

Reference is made to the work of Heisler and Van der Weyde, of Cecil and Leonard Wray, and of thoughts and inspirations such as are always found floating about in scientific circles for

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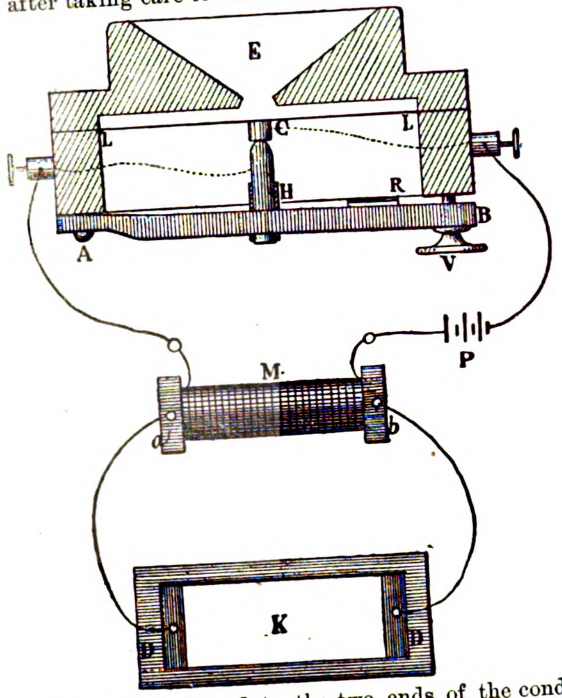
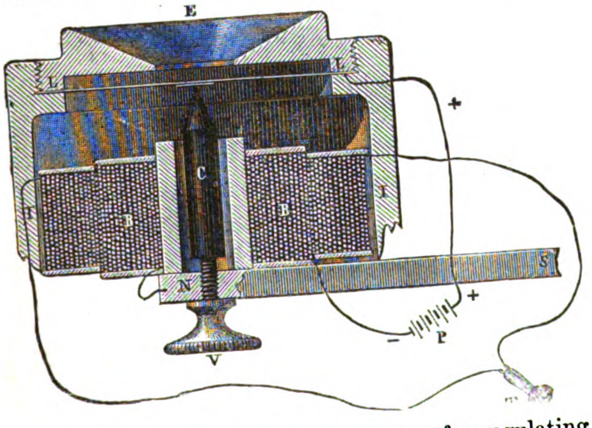
some time previous to the actuality of any great discovery. Pétrina, Gray, and Varley, among others, serve to give material for some pages, and then we come to a description of the singing condenser of MM. Pollard and Garnier :—"The singing instrument consists of a condenser K, formed of thirty sheets of paper, laid one over the other, from nine to thirteen centimetres in thickness: between these, twenty-eight sheets of tinfoil, from six to twelve centimetres thick, are intercalated, so joined as to form the two plates of the condenser. For this purpose the pair sheets are joined together at one end of the copy-book, and the odd sheets at the other end. This system is fastened to a stiff *carton*, after taking care to bind it with a strip of paper, and the

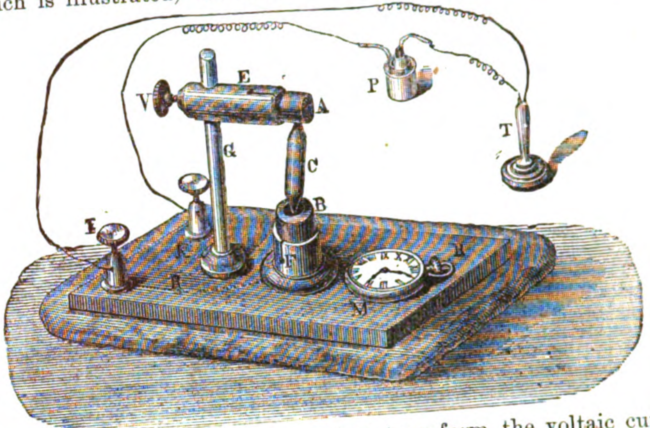


sheets of tinfoil are joined to the two ends of the condenser by two copper rims D, D, which are provided with terminals for the circuit wire, and in this way the singing instrument is constructed. A somewhat heavy weight, placed upon the condenser to compress the sheets, does not in any way prevent it from working; and this vitiates the theory first put forward to explain its effects, that the sheets were moved by attraction. The sending instrument consists of a sort of telephone without a handle, E, of which the vibrating disc is formed of a very thin plate of tin. A cylindrical piece of carbon C is fastened to its centre, and is supported by another cylinder of the same material H. This rests on a transverse piece of wood A B, jointed on the side A,



on the edge opposite to the box, by means of a regulating screw V. An arched spring R (the end of a watch spring) placed across this piece of wood gives it a certain elasticity beneath the pressure, and this elasticity is necessary in order that the instrument may act properly, and it thus becomes a sort of microphone with a diaphragm."

Speaking telephones now come in for attention, and the string telephone is described. By the way, how is it that in England we do not meet with these instruments more frequently? At Paris, during the Exhibition last year, they were constantly in use in the streets, so that every passer-by could experience the effects of the conduction of sound. Bell's telephone is described, and most of his remarks made before the Society of Telegraph Engineers are incorporated in the text. Credit is given to the work of Elisha Gray and a summary of his claims stated. The principles on which Bell's telephone is based are discussed, and a description given of the work of such men as Edison, Gower, Navez, &c. Among the descriptions of instruments is that of M. Hellesen's reaction telephone, which may be interesting to some of our readers. "M. Helleson believed that the vibrations produced by the voice on the carbon of a telephonic sender would be magnified if the moveable part of the rheotome were subjected to an electro-magnetic action resulting from the vibrations themselves, and he has contrived a sender (the principle of which is illustrated) which has the merit of forming in itself



the inducing apparatus intended to transform the voltaic currents employed. This instrument is composed of a vertical iron tube, supported on a magnetic bar N S, and surrounded by a magnetising coil B B, above which is fixed an inducing helix of fine wire I I, communicating with the circuit. Within the tube there is a lead pencil C, held by a porte-crayon which can be raised or lowered by means of a screw V fixed below the magnetic bar. Finally, above this pencil, there is an iron vibrating plate L L, with a platinum point in communication with the battery in its centre; the local circuit communicates with the pencil by means of the magnetising helix B, and for this purpose one end is soldered to the iron tube. From this arrangement it follows that the vibrations of the

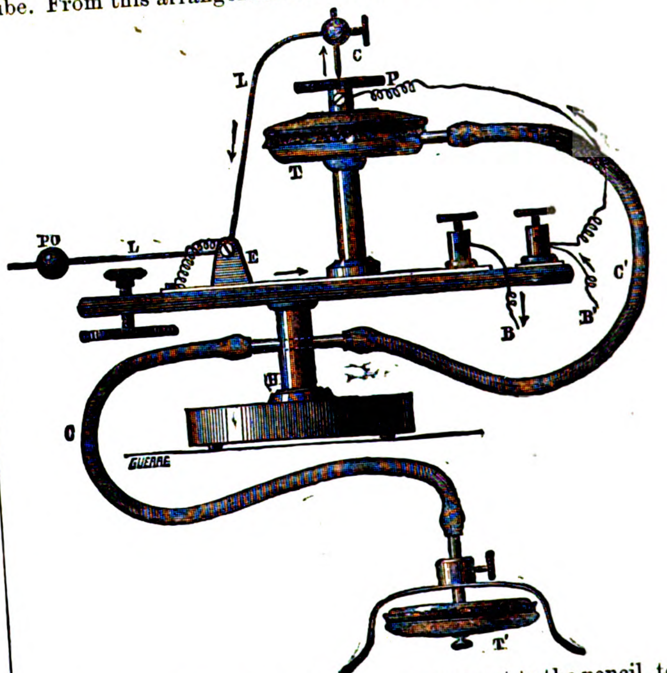


plate L L, at the moment when it comes nearest to the pencil, tend to become greater in consequence of the attractive force exerted on the plate, and as the pressure of the lead pencil is increased, it increases the differences of resistance which result from it, and consequently causes greater variations in the intensity of the transmitted currents."

The reader will find descriptions of almost all the more important forms of telephone, as well as the results of various investigations, making this part of the book of more than ordinary value.

We come to that portion dealing with microphones, and here again the author maintains his simple and exact style, doing

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justice to the discoverer and to those who have modified and adapted the instrument. The illustrations are very clear and good, as will be seen from the above figures illustrating M. Gaiffe's microphone and M. Ducretet's stethoscopic microphone. Of this latter the author says, "It consists of a carbon microphone, C P, with a simple contact, of which the lower carbon, P, is fitted to one of M. Marais's tambourines, with a vibrating membrane, T. This tambourine is connected with another, T¹, by a caoutchouc tube, which is to be applied to the different parts of the body which demand auscultation, and which is therefore termed the *tambour explorateur*. The sensitiveness of the instrument is regulated by means of a counterpoise P O, which is screwed upon the arm of a bent lever, and to this the second carbon C is fixed." We must pass over that portion of the work dealing with "external influence on telephonic transmissions," with various systems of call-bells, with the suggested applications of the telephone, &c., and briefly glance at that portion devoted to the consideration of duplex work.

RECENT PATENTS.

3134. Apparatus for the Dynamical Production and Application of Electricity, *C. H. Siemens.—Dated 8th August*, 1878.—(*A communication.*) 1s. 2*d*.

This relates to improvements on patent No. 2006, dated 5th June, 1873, and consists of making the wires of all the armature coils start from a single metallic ring fixed on the armature, and each wire terminates in a separate insulated plate of a commutator, all these plates being fixed on the axis of the armature and revolving with it. Two sets of metallic brushes or rollers bearing against the plates of the commutator collect and combine the electric currents successively generated in the coils by their passage through the magnetic fields, and the currents so combined are led in parallel directions through the coils of the electro-magnets to the terminals of the apparatus, and thence throughout the external circuit. The carbons of a lamp are adjusted by fixing their lower ends some distance apart in sockets mounted on joints, so that the upper ends of the carbons lean against each other. Between the two carbons is an upright rod of insulating material with its lower end inserted in a piece of soft iron free to slide within a tubular coil of insulated wire which is in the electric circuit of the carbons. When currents pass through the coils and the carbons, the coil being rendered magnetic attracts the iron upwards, and the rod is thus thrust between the upper ends of the carbons. If it should separate them so far that the current ceases to pass, then the currents through the coil being also arrested, the attraction of the iron ceases, and the iron descends, withdrawing the rod, and so allowing the carbons again to approach each other. As the carbons consume away the rod consumes with them.

3837. Electric Light Apparatus, *A. Longsdon.—Dated 28th September*, 1878.—(*A communication.*) 6*d*.

The carbon holders are each suspended by chains from a disc. The disc from which the upper positive holder hangs is twice as large as that of the negative holder. The chains are applied so that when the upper holder goes down by its weight the lower holder is thereby caused to rise, and as the latter only rises half the way the other is descending, it results that the light always occupies the same spot in the room. As the weight of the upper holder, in order to prevent its motion from being influenced by dust, must not be too small, the course of this bar is regulated and slackened by means of a flyer wheel revolving in quicksilver, the axis of the flyer carrying a wheel which gears with a cog wheel on the axis of the discs. In order to prevent a retrograde movement when new carbons are put in, the cog wheel is provided with a rachet wheel. To fix and regulate the distance of the carbons on the axis of the discs and the cog wheel another disc is employed, and on the latter a brake consisting of two parts connected by a link. In the lower part which turns on the common axis is bored a hole in which a pin takes, a certain amount of play being allowed, thus limiting the retrograde movement of that part of the brake. At the upper arm is a brake block, and at the other end an anchor of an electro-magnetic spiral hangs down on a brass bar. When the lamp is in operation the anchor is drawn into the spiral, and the brake block pressed on the brake disc, and in its further advance drives the same backwards as far the regulating screw permits. By this means the upper carbon is raised and the lower one lowered, and the light appears. The carbon is gradually consumed, the current grows weaker, and its effect on the magnet gradually relaxes. The brake assisted by its spring, the effect of which can be regulated through lever and screw, and through the weight of the holders slowly moves backwards, causing thereby the brake disc to move forward and the holders to approach each other. This movement completed thus far, as the brake disc has been previously turned back, the lower part of the break bears against its pin, in consequence of which, if the current continues growing weaker, the brake turns in the link, the brake block releases the disc and the carbons approach each other; the current is thereby strengthened, and the brake again takes on to its disc, either holding it fast if the carbons are in the right position, or fetching it back if they stand too near each other. If the carbons are to be exchanged the brake is fixed by the regulating screw and the work thereby stopped.

TRAFFIC RECEIPTS FOR MAY, 1879.

Companies.	May 1879.	May 1878.	Incrse.	Decrse
Direct United States Telegraph Company ...	15,970	—	—	—
Eastern Extension Telegraph Company	25,845	23,844	2,001	—
Eastern Telegraph Company	38,371	33,650	4,721	—
Great Northern Telegraph Company	18,917	—	—	—

TELEGRAPH SHARE LIST.

Companies.	Closing Prices June 25.	Business Done Week Ending June 25. Highest.	Lowest.
Anglo-American	55, ½	55½	54¾
Do. "B"	84½, 5½	85	84½
Do. "A"	27, ½	27½	26½
Brazilian	6 15-16, 7 1-16	7 1-16	7
Cuba	8¼, ¾	8⅝	—
Do. Ten per Cent. Preference	16, 17	—	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	10¾, 11¼	11¼	11
Direct United States	10¼, ⅝	10⅜	10¼
Eastern	7 11-16, 13-16	7 13-16	7⅝
Do. Six per Cent. Debenture	105, 107	—	—
Do. Five per Cent. do.	101, 103	102½	102½
Do. Six per Cent. Preference	11¼, ¾	11⅝	11¼
Eastern Extension	7¼, ¾	7⅝	7⅝
Do. Six per Cent. Debenture	103, 111	—	—
German Union	7¾, 8¼	—	—
Globe Telegraph and Trust	4¼, ¾	4¾	4¾
Do. Six per Cent. Preference	10¼, ¾	10⅞	10⅝
Great Northern	8⅝, ⅞	8⅞	8 11-16
Indo-European	20, 21	20¼	20⅝
Mediterranean Extension	2½, 3	—	—
Do. Eight per Cent. Preference	8¾, 9¼	—	—
Reuter's	9, 10	—	—
Submarine	225, 235	—	—
West India and Panama	1¾, ⅝	1 9-16	1½
Do. Six per Cent. Preference	7¾, 8¼	8⅛	8½
Western and Brazilian	3⅝, ⅞	3¾	3⅝
West. Union Seven per Ct. 1st Mt.	112, 116	—	—
Do. Six per Cent. Sterling	104, 106	—	—

JOURNAL OF THE SOCIETY OF TELEGRAPH ENGINEERS.

No. 27, Vol. VIII.—SPECIAL NUMBER.

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NOTES.

Cement for Coating Acid Troughs.—Melt together one part pitch, one part resin, and one part plaster of Paris (perfectly dry).

Effects of a Storm on Overland Wires.—During the storm on the 18th and 19th of last April, eighty-two out of the 200 lines which meet at Berlin stopped work on the morning of the 19th, on account of the breakage of poles, wires, and insulators.

Effect of Peroxide of Nitrogen on the Electric Spark.—It has been stated by M. Hempel that when a powerful electrical machine is in full activity, and giving strong sparks, the sparks can be made to cease and the machine to lose all tension if the red vapour of peroxide of nitrogen ($N_2 O_4$) is allowed to escape into the space traversed by the sparks.

Electric Light at the Salon.—The Salon closed at midnight on Monday. The electric light experiment, says *The Times*, attracted many visitors, but has not been an unmixed success. Portraits in general look well by it, but landscapes with grass or water have an unpleasing effect, and the large paintings, which are mostly failures, appear still more decided failures by artificial than by natural light.

Electric Lighting on the Embankment.—The Works Committee of the Metropolitan Board of Works have granted permission to the Société Générale d'Electricité to set up and and work at their own charge a third pair of Electro-Dynamic machines in the engine-house on the Victoria Embankment, with the object of further testing the power of the engine, and the possibility of extending the distance to which the electric current can be conveyed for practical lighting.

Reception Committee.—It may interest some of our readers to know the names of the acting members of "the Joint Reception Committee of the Post Office and the Telegraph Companies" who are now entertaining the Delegates of the International Telegraph Conference. These are:—Sir James Anderson, Mr. W. Andrews, Mr. H. G. Erichsen, Mr. H. C. Fischer, Mr. Douglas Gibbs, Captain Mayne, R.N., C.B.; Mr. W. H. Preece, Mr. Henry Weaver, Mr. Lewis Wells. Secretary, Mr. A. C. Borring.

Intrinsic Energy.—By means of the formula given by Mr. D. G. FitzGerald in *The Electrician* for August 24, 1878, it may be calculated that 1lb. of zinc consumed in a Grove's cell (taking 1·80 volts as the average E.M.F.) would do 1,932,840 foot-pounds of work, and that 1lb. consumed in a Daniell's cell (taking 1·09 volt the E.M.F.) would do 1,170,500 foot-pounds, assuming the whole of the heat produced to be utilised in both cases. But, even theoretically, we cannot assume that more than half this heat would take the form of work. It has been found that 1lb. of hydrogen combining with its equivalent of oxygen is capable of raising 51,146lb. of water 1 deg. Fah.; 1lb. of carbon, 14,500lb. of water; 1lb. of phosphorous, 11,900lb. of water; and 1lb. of sulphur, 2,800lb. of water. One grain of zinc was found to raise only 8lb. 1 foot high by means of an electro-magnetic machine. One grain of coal in the furnace of a Cornish engine will raise 143lb. through the same distance.

Mirror Telegraphy.—Intelligence from the Cape says that communication has been established between Ekowe and Fort Tenedos by mirrors. It may be of interest to state that some four years ago Lieutenant Parrott, of the Volunteer Engineer Corps of New South Wales, conducted a series of very successful experiments in mirror telegraphy. The discs used were about six inches in diameter, of polished metal, covered with glass. At first the distance separating the two mirrors was from six to ten miles, but eventually the system was tested from the Kurnajong Mountain, about 1,500 feet above the level of the sea, to the lighthouse at the entrance to Port Jackson, 400 feet above sea level, a distance direct of nearly forty miles. Communication was kept up throughout the day with perfect success by rapid and prolonged flashes, representing letters, words, and phrases, or, rather, questions and answers. The flashes are, of course, produced by slightly moving the mirrors. Successful tests were also effected by moonlight for a distance of four or five miles, and on dark, clear nights this system of telegraphy may be carried on by means of lamps with powerful reflectors, the light therefrom being thrown on to the signalling disc. The advantage of this mode of communication during war is apparent to every one.

Visit to Windsor of the Delegates of the Telegraph Conference.—At the invitation of Sir Daniel and Lady Gooch, the Delegates to the International Telegraph Conference paid a visit to Windsor on Saturday, June 28 A special train took the visitors, about sixty ladies and gentlemen, to Windsor at 10:20, and on arrival they were shown, by the kind permission of Her Majesty, over the Castle. Sir J. Cowell himself took charge of the party, and Sir Henry Ponsonby joined it in the Queen's private apartments, which the Queen, with her usual kindness, had allowed also to be shown, although they are inhabited by Her Majesty at this present moment. In one of the rooms the cloth was actually being laid for the Queen's luncheon, and a unanimous feeling of grateful surprise at Her Majesty's gracious consideration was expressed in many tongues. The treasures of the finest Royal residence in Europe and the beautiful views from different windows having all been seen and appreciated, the party proceeded to the Prince Consort's Memorial Chapel, and afterwards St. George's Chapel. Sir G. Elvey gave a special performance on the organ. At one o'clock Sir Daniel and Lady Gooch entertained their guests at luncheon at the Town Hall, Windsor. The "Health of Her Majesty," given by Sir Daniel Gooch, was drunk with enthusiasm, and General Lüders proposed the health of the hosts in French, adding that what they had seen that day had far surpassed their expectations. After luncheon the party took a drive to Virginia Water, and, after resting at the Wheatsheaf, returned to Windsor in time for the special train, which left for Paddington at six o'clock.

The "Daily News" and Mr. Edison.—We have a firm conviction that Mr. Edison is not answerable for one-thousandth part of the newspaper paragraphs containing statements which are frequently as absurd as they are incorrect. The editor of the *Daily News* ought to be better informed and take more care than to go to the expense of a special telegram, and flaunt before the faces of his readers in

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big type such a paragraph as he inserted on July 2. The following is the telegram:—"Mr. Edison has obtained a dynamometer of sufficient delicacy to measure every one-hundredth of horse-power. With this instrument he can calculate the cost of the electric light to the minutest detail. He has demonstrated that from eighty to ninety per cent. of energy is converted into light, and that six electric lights are supplied from one horse-power at one-third the cost of gas. He maintains that the problem of applying the electric light to domestic use has been practically solved, but admits that a great mass of detail remains to be worked out. He has satisfied himself that platinum can be supplied in large quantities so as to reduce the expense. Recently he has been working on the electro-chemical telephone exchange system, which is now perfected for introduction in London. He will now give his time exclusively to the electric light, and is confident that his system will soon be in perfect order."—[At the meeting of the Mechanical Engineers last April, Dr. Hopkinson read a Paper, which was published by us on May 3, and in our contemporaries, *The Engineer* and *Engineering*, the following weeks. Let our readers refer to Dr. Hopkinson's Paper, and then consider the value of the *Daily News* paragraph. We have often pointed out the miserable failure our political papers make when dealing with scientific questions. It is not that they cannot, it is because they will not take advice from some scientific friend. The reputation of Mr. Edison suffers from the publication of such paragraphs, and the public is falsely led to conclude that something of vast importance, hitherto unknown, has been discovered.]

On the Deviations of Ampere's Theory of Magnetism from the Theory of the Electro-magnetic Forces (by J. Stefan).—The divergences between the two theories stand out most clearly when the moments with which a current-element tends to rotate an elementary magnet are determined according to both. According to the electromagnetic theory, the current-element rotates the magnet out of the plane when both stand perpendicular to the line joining them and are situated in the same plane; while according to Ampère it cannot act at all upon the elementary current equivalent to the magnet, since it stands perpendicular to every part of the latter and at the same time to the connecting lines leading to them. If the current-element falls into the connecting line, according to the electromagnetic theory it exerts no rotating action upon the magnet; but according to M. Ampère it sets the equivalent elementary current continuously rotating about its axis—an action which is quite foreign to the electromagnetic theory. If the magnet lies in the direction of line of conjunction, a current-element perpendicular to this, according to both theories, rotates the magnet out of the plane, but according to Ampère's theory with a moment twice as great as according to the electromagnetic. For closed circuits the differences compensate one another, but the parts which the individual elements of the circuit have in the total action are different. Thus, according to the electromagnetic theory, the elements of the vertical circuit of a tangent-compass all act with equal deflecting force upon the very short needle; according to Ampère the elements situated in the vertical diameter exert no action, while those in the horizontal diameter act twice as powerfully as according to the other theory. In the memoir the electromagnetic is compared with the general electrodynamic theory, which also assumes transversely-acting forces, and was developed by the author in his memoir "On the Fundamental Formulæ of Electrodynamics," published in vol. lix. of the *Sitzunsberichte* of the Academy (1869). The comparison has reference, first to the forces, and, secondly, to the pairs of forces, which a current-element exerts upon an elementary current. In the former respect Ampère's theory, and all those which also assume transversal forces, though of such a nature that they cannot move the common centre of gravity of two current-elements, agree with the electromagnetic theory. In the second respect the electromagnetic theory corresponds only with Grassman's. But as these two theories differ in the expressions for the forces, there is not any electrodynamic theory containing in itself the electromagnetic. With the exception of Grassman's, all the theories contain, though not in like manner, continuous rotations of the magnets by the action of the component of the current element in the connecting line.

A New Arrangement of the Galvanometer for Absolute Measurements.—In the ordinary arrangement of the galvanometer, says Prof. N. D. C. Hodges, the current is measured by the ratio of the force it exerts on the needle to the directive force of the earth, the ratio being determined by measurement of the angle of deflection. The moment of force with which a unit current acts on a needle may be expressed in a series of the form

$$G_1\, g_1 \sin\theta + G_2\, g_2 \sin\theta\, \phi_2'(\theta) + \text{etc.},$$

where G_1 G_2 are constants depending on the dimensions of the coil, and g_1 g_2 on those of the suspended apparatus, coil or magnet, as the case may be. $\phi_1'(\theta)_1$ $\phi_2'(\theta)$ are quantities varying with the deflection. Only when all terms after the first may be neglected, are the values of the current proportional to the tangents of the deflections. If, instead of placing the plane of the coils parallel with the magnetic meridian, they are placed perpendicular to it, the sum of the force of the current and of the directive force of the earth would influence the magnet. The formula $\frac{t_i^2}{\pi^2} = \frac{K}{MT(1+\theta)}$ expresses the relation between the time of vibration of a horizontal magnet, with moment of inertia K, magnetic moment M, the horizontal component of the earth's magnetic force being T. If this time of vibration without the current is first taken and then the time t with the current, the relation

$$\frac{t^2}{t_i^2} = \frac{T+F}{T} \text{ or } \frac{t^2 - t_i^2}{t^2} = \frac{F}{T},$$

where F is the directive force of the current on a magnet of unit magnetic moment; and

$$C\,(G_1\, g_1 + G_2\, g_2\, Q_i^1(\theta) + \text{etc.}) = F.$$

The factor may be considered constant for small angles, and equals the constant of the instrument used as a tangent galvanometer, when the deflection is supposed = 90°. If $G_1 g_1 + G_{i2} g_2 Q_1'(0°) + \text{etc.} = K_{90}$, then $F = C K_{90}°$; and $C = \frac{t^2 - t_i^2}{t_i^2} \frac{T}{k_{90}°}$. To find the value of $K_{90}°$, the same current, if passed through the instrument used as a tangent galvanometer, will give

$$C = \frac{T}{k\phi} \tan\phi\,; \text{ whence } K_{90} = \frac{(t^2 - t_i^2)\, k\phi}{t_i^2 \tan\phi}.$$

If the value of $k\phi$ is known for any value of ϕ', the deflection, the constant of the instrument used in this other way is given by this formula. The relative values of $k\phi$ for different values of the deflection of a tangent galvanometer may be found by repeated application of this process, or any of the usual methods for finding the constant of a galvanometer would apply.

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A NEW THEORY OF TERRESTRIAL MAGNETISM.

BY PROFESSORS JOHN PERRY AND W. E. AYRTON.*

(CONCLUDED FROM PAGE 65.)

Assuming Biot's distribution of magnetic force over the surface of the earth, which is also what our theory has led us to, we then get from Gauss's expression for the moment the result that the magnetic potential on the earth is $0{\cdot}33092 \cos\theta\, n^{-\frac{1}{2}}$, or $0{\cdot}00001311 \cos\theta$ nearly; so that roughly we have, for a point on the earth's surface,

$$\frac{16\pi}{3}\sigma w = 0{\cdot}00001311.$$

But

$$w = \frac{2\pi}{24 \times 60 \times 60};$$

∴ the density $\sigma = 0{\cdot}0107$ unit of electricity, or the total charge $= 4\pi \times 0{\cdot}0107$, the fundamental units of space, mass, time being the radius of the earth, the gramme, and the second. But the dimensions of σ are $M^{\frac{1}{2}} L^{\frac{1}{2}}$; so that, in order to express σ in C.-G.-S. units, we must multiply by $\sqrt{n}$; therefore the total charge

$$= 4\pi \times 0{\cdot}0107\sqrt{\frac{2{,}000{,}000{,}000}{\pi}} \text{ C.-G.-S. units}$$

$$= 4\pi \times 0{\cdot}0107\sqrt{\frac{2{,}000{,}000{,}000}{\pi}} \times 10^7 \text{ microfarads.}$$

To get an idea of the electromotive force required to produce this charge, let us imagine one pole of a Daniell's battery connected with the earth and the other with all bodies in space. Then, since the capacity of the earth is 630 microfarads, this charge will be produced for each cell so employed: so that, if x is the number of cells necessary to produce our required distribution,

$$x = \frac{4\pi \times 0{\cdot}0107 \times \sqrt{\frac{2 \times 10^9}{\pi}}\, 10^7}{630} = 54 \text{ million roughly.}$$

We have, therefore, proved that if the earth be electrified, it must, from its very rotation, quite independently of all other bodies in the universe, be magnetic; and if it consist of a shell of iron, thick or thin, then that the law of distribution of magnetism produced by this electric charge in mechanical rotation will be identically that given by Biot; and lastly, if the earth were wholly of iron, a difference of potentials of about fifty-four million volts between it and space would be sufficient to produce the necessary amount of charge.

Now, although fifty-four million volts is a large difference of potentials to be produced with a galvanic battery, there would not be the slightest difficulty in the earth having such a difference of potentials between it and space, seeing that the earth is surrounded by millions of miles of interplanetary space, every inch of which is as good or better an insulator than a Crookes's vacuum; and it has been experimentally shown that many thousands of cells will not cause a discharge across even a comparatively thin film of such a vacuum.

But even without considering the highly insulating character of interplanetary space, we see from the experiments of Drs. De La Rue and Hugo Müller that the electromotive force of fifty-four million cells cannot, in all probability, initiate a spark between two points in ordinary air unless the distance separating them be less than four hundred feet. Consequently, if the electric charge which by its mechanical rotation produces the magnetism be on the earth itself and not in the air, it could not be discharged by sparking, unless another planet, having at least a potential nought relatively to the earth, came at least to within four hundred feet of its surface.

Next, as regards the sign of the electric charge on the earth's surface required to produce the earth's magnetic polarity, is it in accordance with the known phenomena of atmospheric electricity? To produce the earth's magnetism, we must have, in accordance with the known laws of electro-magnetism, a *negative* current flowing from west to east, or in the direction of rotation of the earth. In the language of the new theory, therefore, the surface of the earth must be *negatively* charged; but Sir William Thomson has proved, by observations with his electrometer, that *all* the phenomena brought to light by atmospheric electricity, on a fine day, could be produced by the sole agency of the earth having a *negative* charge and without any charge in the air itself. The negative charge, therefore, required for our explanation of the cause of terrestrial magnetism is sufficient to account for all the ordinary phenomena of atmospheric electricity.

In the preceding investigation we have supposed the electric charge to be uniformly distributed over the earth, and so have arrived at a law of magnetic intensity merely varying with the latitude. But the sun and other members of the solar system may very likely have potentials so different from that of the earth that we can hardly conceive the amounts; consequently, we should expect the static electric distribution of the earth would undergo periodic changes corresponding in time with those of the ocean-tides. But alteration in the static distribution of electricity on the earth's surface means, as we have shown, alteration in the law of magnetic intensity; consequently, we should expect that this magnetic intensity would vary somewhat as do the ocean-tides; and this is known to be the case. But it is also evident that, besides these regular changes, every time a great mass of vapour is suddenly formed and condensed on the earth, and whenever great changes are occurring in the solar atmosphere whereby the lines of *electrostatic induction* from the sun to the earth are altered we should find corresponding changes in terrestrial magnetism such as we now know as magnetic storms. And not only this, but, as the planets are charged bodies, their motions relatively to the sun ought to cause motions in the sun's atmosphere such that, for instance, the allineation of a number of planets and the sun, or the near approach of any planets, if the alligned or approached planets have potentials nearer that of the sun than many of the other bodies of the solar system, ought to diminish the storms in the solar envelope, and ought to alter the electrostatic distribution on the earth. But it has been shown that the near approach of a planet to the sun both affects the sun's spots and terrestrial magnetism.

And, lastly, since the iron in the earth may, from its great pressure, possess great coercive force, we should expect (as we know to be the case) that magnetic changes would lag behind the astronomical influences accompanying them.

Addition, April 17.—Since the reading of this Paper before the Physical Society, several criticisms have appeared of this proposed explanation of terrestrial magnetism. Some of the writers have failed to realise that the various parts of a rotating sphere have relative motions one to the other, of such a nature that if some were electrified the others would become magnetised. Their difficulty seems to have arisen from the fact that the motion of a particle of a rotating rigid sphere consists of a rotation round the axis of the sphere combined with a rotation of the particle round its own axis; so that if two particles be looking at one another in one position of the sphere, they are looking at one another in all positions, just as the same side of the moon is always turned to the earth. But if this rotation of the particles round their own axes could be stopped; if, in fact, the motion of the particles became what is commonly known as "sun-and-planet motion" (similar to that of the bobbins in the machinery used in sheathing telegraph cables to prevent torsional strain being put into the iron wires as they are lapped on the core), then probably these writers would have no difficulty in seeing that the interior particles would be magnetised by the more rapidly moving electrified ones. Now, the motion of an *un*electrified particle round its own axis cannot in any way prevent it becoming magnetised by electrified particles revolving round it; for if it could, it would be equivalent to saying that, if the electrified particles were at rest and the *un*electrified one revolving, the mere revolution of the latter would magnetise itself oppositely to the way it would be magnetised if it were at rest and the electrified ones only in motion—a result not only without experimental proof, but one also highly improbable. Consequently, if the particle has the two motions together (as it has in a rigid revolving sphere), it will still become magnetised if the surface of the sphere is electrified.

In fact, so little can the motion of a mass of iron—*unelectrified, either conductively or inductively*—prevent its becoming magnetised by a moving charge of electricity, that it has been suggested to us, within the last few days, by Mr. G. F. Fitzgerald, of Trinity College, Dublin, that probably a mass of *un*electrified iron would become magnetised by a static charge of electricity if both had rapid absolute motion in space, even although in the same direction in parallel lines and with the same velocity—in fact, that *relative* motion is unnecessary.* If this assumption (which has not yet been experimentally tested) be true, then not only will the mathematical analysis required in the investigation of the problem contained in this Paper be much simplified, but,

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* Communicated by the Physical Society, having been read at the meeting on March 8.

* It would, of course, be impossible to try this experiment in this simple way, since practically there would be induced on the magnet, or on any metal box by which it might be surrounded, a charge of electricity *opposite* to that of the inducing body. But if a magnet were enclosed in an electrified rotating conductor then probably the action on the magnet would be exactly the same whether the magnet were at rest or revolving with the electrified conductor surrounding it.

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in addition, the charge of electricity on the earth's surface necessary to produce, by its mechanical rotation, the earth's known magnetic movement will be considerably less even than the charge calculated above. We hope to put this idea of Mr. Fitzgerald's shortly to an experimental test; but, in the meantime, we give no further indication of the reasoning by which it has been arrived at, nor of the way in which our equations would be modified, preferring to leave the investigation in a perfectly rigid form as it now stands, rather than to introduce any assumption which might appear problematical, even although such an introduction would both add weight to our theory, and might explain, from the velocity *in space* of a place at midnight being greater than at midday, the cause of the solar-diurnal magnetic variation.

We have shown that, in order that the actual magnetic moment of the earth, as determined by Gauss, may be produced by convective currents, there must exist on its surface, if the earth were solid iron, a *negative* charge of

$$4\pi \times 0\cdot0107 \sqrt{\frac{2 \times 10^9}{\pi}} \text{ C.-G.-S. electro-magnetic units,}$$

or, 1011×10^{11} C.-G.-S. electrostatic units.

As far as the *sign* of the charge is concerned, we have seen that this agrees with the phenomena of atmospheric electricity (Sir William Thomson's inaugural address to the Society of Telegraph Engineers, 1874). Let us now examine whether the observed phenomena of atmospheric electricity justify us in considering that the earth has so large a negative charge. A large number of experiments on atmospheric electricity have been made in England, France, Italy, &c., and in some more southern countries. All tend to show that the potential of the air in fine weather is positive to the earth, that is the surface of the earth is negatively charged, but as the majority of these observations have been made with "water-dropping collectors," the spout of which projects a short distance through the window of the house, and is more or less overshadowed by the house walls, they cannot be used to determine the absolute atmospheric difference of potentials per foot of elevation, since the overshadowing wall tends to diminish the difference of potentials between a point in the air and the earth, and consequently causes the result for a given elevation to be too low. We must take, therefore, in our rough calculation of the entire negative electric charge in the earth the results of the experiments made by Sir W. Thomson on the sea beach in the Island of Arran and on the Links near Aberdeen. Sir W. Thomson finds that in fair weather the potential of the air is positive to the earth, and increases positively as we ascend, the usual rate of increase being from 22 to 44 volts per foot of elevation in the open country, in places not overshadowed by trees or buildings. (Papers on "Electricity and Magnetism," Art. XVI., pp. 219 and 229). From this it may easily be proved, if we take 30 volts as a mean value per foot of elevation, that the resultant electric force at the earth's surface has a mean value of

$$\frac{30 \times 10^8}{298 \times 10^8 \times 31} \text{ C.-G.-S. units}$$

(Papers on "Electricity and Magnetism," Art. XVI., p. 29). Consequently, the total electric charge on the earth's surface is

$$\frac{30 \times 10^8 \times 4\pi r^2}{298 \times 10^8 \times 31 \times 4\pi} \text{ C.-G.-S. electrostatic units,}$$

where r is the earth's radius in centimetres.

The probable *actual* charge, therefore, equals

$$1364 \times 10^{12} \text{ C.-G.-S. electrostatic units,}$$

or about *fourteen* times as great as would be necessary to produce the earth's known magnetic moment if the earth were solid iron. We have, therefore, a large margin to allow for the earth not being solid iron.

It is important to notice that, for the reasons given above, any charge in the higher regions of space will not affect the earth's magnetism since such a charge will be at rest with the earth revolving inside it.

Again, does our explanation, that the cause of terrestrial magnetism is due to the convective current produced by the static electric charge in the rotating surface of the earth that is *under us*, agree with existing knowledge regarding the position of the cause? Yes; for in Clerk Maxwell's "Electricity" it is shown that, by observation of the direction and intensity of the horizontal component of the earth's magnetism only, it is possible to express the magnetic potential at any point on the surface of the earth in the form of a series of spherical surface harmonics, from which it can be proved that the principal part of the earth's magnetism is not produced by the direct action of any cause exterior to the earth.

THE RISE AND PROGRESS OF SUBMARINE TELEGRAPHY.*

(CONTINUED FROM PAGE 41.)

The cable was made in accordance with the foregoing stipulations and improvements, and the last mile completed on the 29th of May, 1865.

The services of the ss. Great Eastern had been fortunately secured, and she was specially fitted for the undertaking with three enormous water-tight tanks capable of containing when full 2,490 knots.

The paying-out machinery was designed by Mr. Canning and Mr. Clifford, but Appold's brake was still retained.

H.R.H. the Prince of Wales, accompanied by a distinguished party, visited the Great Eastern at Sheerness, and was received on board by Mr. John Pender, the chairman, and Mr. Glass, the managing director, of the Telegraph Construction and Maintenance Company.

On the 14th of June, 1865, the required cable having been taken on board the Great Eastern, she commenced her voyage, under the command of Captain, now Sir James Anderson, who had been chosen as one of the ablest commanders in the mercantile marine.

She arrived safely on the west coast of Ireland, and lay at Berehaven, while the ss. Caroline laid the shore end in Foilhummerun Bay, on the opposite side of the Island of Valentia to that selected for the cable of 1857. This was completed on the 22nd July, and twenty six miles of cable paid out and buoyed in readiness to be taken up and spliced to the cable on board the Great Eastern, which was successfully accomplished the following morning.

Mr., now Sir Samuel Canning, C.E., was in charge of the whole arrangements for landing, and paying out the cable; assisted by Mr. Clifford, Mr. Temple, Mr. London, and others. Mr. De Sauty had charge of the electrical department, assisted by Mr Saunders and Mr. Willoughby Smith, &c. Mr. Varley, associated with Professor, now Sir William Thomson, and staff, were present on behalf of the Atlantic Company, to report on the laying of the cable, and to see that the conditions of the contract were complied with.

A careful system of testing and signalling had been drawn up for the guidance of the electricians ashore and on board.

Professor Thomson's marine galvanometer, which had been greatly improved since its first employment in the 1858 Atlantic expedition, was to be used for testing and signalling. This instrument will be fully described to you in detail in a future lecture.

On the completion of the splice between the shore end buoyed by the Caroline, and the cable on board the Great Eastern, paying out was commenced, and everything went well until 84 miles had gone out, when a flaw was suddenly detected by the electricians, which considerably taxed their ingenuity and skill to localise. However, they at last came to the conclusion that it was not very far astern, and there was nothing for it but to commence hauling the cable on board.

The great ship was turned round, the cable brought over the bows, and picking up commenced, by means of the machinery, which had been specially provided for such contingencies. Under these circumstances she behaved admirably, and as Mr. Russell observes, "so delicately did she answer her helm, and coil in the film of thread-like cable over her bows, that she put one in mind of an elephant taking up a straw in its proboscis." At last, when about ten miles of cable had been brought on board, the fault was discovered, and turned out to be a piece of wire about two inches in length, of the same kind as was used in the sheathing of the cable, which had become forced through the outer covering and gutta percha, so as to make contact with the copper conductor. Measures were at once taken to make a joint and splice with the cable on board, having removed the faulty piece. This done, and the electrical condition being perfect between the Great Eastern and the shore, she once more proceeded, when all of a sudden electrical communication between the ship and shore ceased. This, however, proved to be a false alarm.

Everything now went splendidly, and the insulation improved steadily, as more and more of the cable became submerged in the deep cool water. Seven hundred and sixteen miles had been layed, and every one's confidence had been gradually increasing in the admirable qualities of the great ship, when at 3 p.m. on the 29th of July "*dead earth*" suddenly appeared.

The whole operation of paying out had to be suspended, and picking up, with its attendant risks, once more brought into play.

When there are no faults, paying out is a matter of mere

* Lectures on Submarine Telegraphy, delivered at the Malta Station to the staff of the Eastern Telegraph Company, by A. Jamieson, C.E.

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routine; but when the operation has to be reversed, a moment's neglect, a swerve of the helm, or the slightest accident, and the cable snaps and sinks to the bottom of the ocean.

After nineteen hours of hard work, the fault was brought on board, communication with Valentia re-established, and paying out recommenced.

This second fault appeared so similar to the former, and the concomitant circumstances were so apparent, that everyone fancied there was clear demonstration of foul play. So strong was the feeling of anger and indignation, and so determined were those in charge to prevent a similar recurrence, that Mr. Field with other gentlemen took turn about in supervising the operations in the tank.

For two more days after this accident everything went so well that those on board were beginning to speculate on the prospects of a successful termination to their labours; when all at once, on the morning of August 2nd, another bad fault appeared. These repeated hitches caused great anxiety, but, as the former means of repairing the injuries had been so successful, cutting the cable, and picking up was again resorted to, although the depth was known to be over two thousand fathoms.

This time, however, success did not favour them; for, after a portion of the cable had been brought on board, the picking-up machinery refused to work, owing to deficiency of steam; and while this was being remedied the wind shifted, rendering it difficult to keep the ship's head up to the cable, which at length caught against the hawse pipes and became so chafed that it parted, on picking up, with a crash, causing the greatest bitterness and disappointment.

Three different times was the cable caught, and lifted for considerable distances from the bottom; but each time some part of the grappling system gave way; until every available fathom of grappling rope was exhausted. Ultimately the expedition had to be given up for that year; although everyone must admire the pluck and determination of those engaged in combating the odds against them.

Not only was the weather unfavourable, from the dense fog which prevailed at times, but the gear, ropes, and shackles, provided were not equal to the occasion. One grand fact, however, was proved; namely, that it was by no means impossible to grapple for, and hook a cable in 2,000 fathoms of water; and were the cable only strong enough, and laid with the necessary slack, to permit of its elevation, there was no reason why it should not be repaired successfully.

The first disappointment over, from the failure to connect England and America, the directors raised a new company, and called it the Anglo-American Telegraph Company (Limited), with a capital of £600,000, which was to act as the agent of the former Atlantic Telegraph Company; and, if successful, the new company was to work both cables and receive an annual payment from the Atlantic Company out of the earnings.

The materials and construction of the new cable were to be in every way the same as that of the 1865 cable, except that the iron sheathing was to be softer, and the hempen covering of the iron wires was not to be saturated with tar.

Two of Her Majesty's ships, the Terrible and Albany, were again appointed to assist the Great Eastern. The new and old cable, comprising in all about 2,600 miles, had been safely coiled on board, and the electrical condition proving perfect, the expedition sailed for Valentia, where the shore end was landed on the 13th of July, 1866, and the cable layed across to Heart's Content with scarcely a hitch, where the other shore end was safely deposited on the 17th of the same month.

One great element of safety adopted in laying this cable was that of limiting the ship's speed to five knots an hour. This I beg to call your attention to, as a very important matter, not only from the greater chance of stopping the ship more quickly should a foul flake or fault occur, but from its allowing the cable to sink more gradually, consistent with the sinuosities of the bottom.

After completing this section, the attention of those on board was at once directed to raising the end of the 1865 cable, where it had been abandoned.

H.M.S. Terrible and Albany preceded the Great Eastern to the ground, where the latter hooked and buoyed the cable on the 12th August; but, owing to a defective weld in one of the links of the buoy chains, she lost it again with two miles of new rope.

After hooking the cable several times from the Great Eastern without success, it was brought to the surface, but, unfortunately, parted at the bow sheave.

Having been so far unsuccessful on their present fishing ground, they started for a position some eighty miles eastward, where the water was supposed to be shallower, and the chance of success therefore correspondingly greater.

This time a new plan was adopted. In the first place, the cable was caught, lifted within 800 fathoms of the surface, and buoyed to the grapnel rope. Another grapnel was lowered some three miles to the westward of this buoy, where the cable was again caught and lifted to within 800 fathoms of the surface. At the same time the cable was caught by the Medway two miles further west, and she continued hauling up until the cable parted on her grapnel about 300 fathoms from the bows. Thus the cable was in the most favourable circumstances for lifting by the "Great Eastern." She, therefore, commenced hauling in, and at 1 a.m. on Sunday morning, September 2nd, the grapnel made its appearance above water, with the cable secured on three prongs. On its being taken to the testing-room a breathless suspense overcame every one, which was followed by the gratest delight, on the electrical condition between the ship and Valentia being pronounced perfect. No time was lost in making a joint and splice, and in a few hours the ship was on her way to Heart's Content, which was successfully reached on the 8th September. Courage and perseverance on the part of those engaged had thus won their well-merited success, and the two great continents were linked together by a double tie of communication.

(TO BE CONTINUED).

INTERNATIONAL TELEGRAPH CONFERENCE.—VISIT TO WOOLWICH ARSENAL.

On Wednesday last the Delegates to the Conference, together with a large number of guests, including some ladies, who had been invited to accompany them by the Reception Committee of the Post Office and Telegraph Companies, assembled at 10:30 on the Blackfriars steamboat pier, where a specially-chartered steamer was waiting to convey them to Woolwich, in accordance with arrangements made under authority of the Secretary of State for War. Amongst those present on board were Colonel Champain, Sir James Anderson, Mr. C. W. Preece, Sir J. Carmichael, Mr. Ansel, Professor Huxley, Dr. C. W. Siemens, Dr. Carl Siemens, Mr. F. C. Webb, Mr. F. H. Webb, Sir F. Goldsmid, Mr. Latimer Clark, Sir Charles Bright, Mr. W. Andrews, General de Lüders, M. V. do Rego, M. Z. Radoycovitch, Mr. Graves, Mr. Winter, M. Vinchent, Mr. Desmond FitzGerald, Mr. Douglas Gibbs, Dr. Sommerschild, Mr. Erichsen, Mr. A. Chambre, Mr. Cunningham, and Mr. J. Aylmer. On their arrival at Woolwich, after having encountered a series of heavy showers, varied by short intervals of sunshine, the party were received at the arsenal by Professor Abel, General Younghusband, and other officers, and were unfortunately greeted also by the heaviest downfall that occurred during the day. After some delay, due to this cause, they were conveyed, in four divisions, by the arsenal railway to Woolwich Marshes, where they had the opportunity of witnessing the running of a fish torpedo, a series of experiments illustrating, on a somewhat large scale, the properties and power of gun-cotton, and the firing of the 38-ton gun. The party then returned by rail to the arsenal, where an excellent luncheon awaited them at the Royal Carriage Department Iron Store. The chairman of the day, Sir James Carmichael, presided at one of the tables, amongst the other occupants of which were Mrs. Champain, Mesdames Lasard, do Rego, de St. Martial, and Despecher. Mrs. Patey, Lady Anderson, Mrs. and Miss Siemens, Admiral Sir H. Keppel, Lord Rosse, M. D'Amico, Sir Julian Goldsmid, Sir George Elliott, Colonel Hayman, M. Richard, Dr. Brunner von Wattenwyl, Colonel Frazer, General Younghusband, and Herr Budde. Amongst those to whom was delegated the pleasant duty of presiding over the remaining tables were Mr. T. Fuller, Mr. Fischer, Dr. C. W. Siemens, Sir J. Anderson, Colonel Champain, Mr. Weaver, Captain Mayne, and Mr. Preece. To the untiring activity and care of the latter gentleman, supplemented as it was by the endeavours of all who could minister to the enjoyment of the party, must have been, in great measure, due the success of a day which, in spite of the *contretemps* of weather, will, we think, be marked by a red letter in the record of the pleasant time spent by the Delegates and their friends.

After luncheon the whole party proceeded to the Royal Gun Factories, where they had the opportunity, which was evidently highly appreciated, of witnessing the stupendous operations carried into effect by the coiling machine, the large rolling mill, and the 40-ton hammer. They then passed on to the shrinking pits, where a 38-ton trunnion jacket was being lowered on to its core, and, after traversing the various "shops" of the Royal Gun Factory, Royal Laboratory, and Royal Carriage Department, the Harness Store, Shell Foundry, &c., proceeded to the pier, where their steamer was waiting to take them back to London. For our own part, we must say that the expressions which we heard of appreciation and admiration of the manner in which the Reception Committee are performing their task, appear to be fully merited.

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THE ELECTRICIAN.

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PARLIAMENT AND ELECTRIC LIGHTING.

In the ordinary affairs of life it is a commonly received maxim that, if you don't know what to do, the best thing is to do nothing. In Parliament the plan is to grant a select committee. It generally amounts to the same thing in the end; but the process is more costly, more pretentious, and occasionally more dangerous. Select Committees, however, have at all times a usefulness which well repays the cost and the risk. They act as safety valves for the undue pressure of public opinion. A rule which is very good for individuals does not hold good for the multitude; and when the House of Commons is pressed on all sides to do something, but does not know what, it very wisely tells-off a few of its members to institute a formal inquiry. This looks like action; and by the time this first slow step has been taken, the pressure has abated, public ardour has cooled down—and there the matter practically ends. Of course there is a Report; and of course the Newspapers comment upon it as if they understood all about it, and were intensely interested—and then it is forgotten. There are, it is true, other minor advantages attending Parliamentary Committees, such as, for example, providing impecunious members with lucrative occupation, and eminent chairmen with opportunities for writing able essays, which can be quoted years afterwards with an "I told you so" kind of air; but in the main these extra legislative functions serve merely to allay popular excitement, and prevent anything being done in a hot haste.

We cannot, as yet, confidently predict that this useful service will be effectually rendered by the Parliamentary Committee which has just reported the result of its laborious investigation of the capabilities and prospects of Electric Lighting; but we can certainly say of its Report that it does not betray any unaccustomed vigour, dangerous activity, or alarming cleverness, calculated to put other documents of a similar kind to shame. It is as mild as the most *laissez faire* administration could desire; and as nobody, so far as we are aware, seriously wanted anything done, the Committee deserve to have satisfied everybody. There was nothing at all to be done and the Committee have done it thoroughly.

Their Report, however, is singular in some respects; and though it may not deserve much attention it provokes a few obvious comments. First there is the opening dissertation on the scientific aspect of the question, somewhat out of place, and a trifle inconsequent, but naturally expected with Dr. Lyon Playfair in the chair. Anybody taking up this Report expecting to see in it the concise and practical conclusions of a set of business-like men, or the wisdom which is said to come of a multitude of counsellors, will at once find out their mistake. There is only one voice; and what it says is somewhat commonplace. We are told that the Electric Light is "an evolution of scientific discovery which has been in active progress during the whole of this century." But perhaps it was necessary, from the statesman's point of view, to counteract the popular notion that the Electric Light is a quite recent evolution. Further on the report observes:—

> "A remarkable feature of the electric light is that it produces a transformation of energy in a singularly complete manner. Thus the energy of one horse-power may be converted into gas-light and yield a luminosity equal to 12 candle-power. But the same amount of energy transformed into electric-light produces 1,600 candle-power."

The question here naturally occurs:—To whom is this piece of information addressed? If to the scientific public, they certainly do not need it, and might take exception to it, stated in that crude way. If to the general public, they obviously need some further explanation of this apparent waste of the energy at our disposal. We soon discover however that it is put forward only to draw a sharp distinction between "practical" witnesses and "scientific" witnesses:—

> "It is not therefore surprising that while many practical witnesses see serious difficulties in the (*sic*) speedy adaptation of the electric light to useful purposes of illumination, the scientific witnesses see in this economy of force the means of great industrial development, and believe that in the future it is destined to take a leading part in public and private illumination."

This is not at all complimentary either to the scientific men who are thus set down (quite unintentionally of course) as unpractical visionaries; or to the practical men, who, it would seem, refuse to be duly impressed with the remarkable economy of force referred to.

The Committee then proceed to report on what most people would call facts, but what appear to be regarded by select committee-men as mere pieces of evidence. "There seems to be *no reason to doubt* that it (the electric light) has estab-

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lished itself for lighthouse illumination." There is no reason to doubt, either, that "it is used in Paris for lighting certain shops, and has recently been used in England for the same purpose." This is safe; as also the statement that many trials have been made for street illumination "with greater or less success"—whatever that may mean. "Compared with gas, the economy for equal illumination does not yet appear to be conclusively established;" and, "so far as we have received evidence, no system of central origin and distribution suitable to houses of moderate size has hitherto been established." This is no doubt all true enough; only one would like to know what meaning, or meanings, the author of the paper attaches to the oft-repeated word "established."

The Committee are pretty clear upon some points. First that Gas companies have no special claim to be considered. Second that Corporations should be allowed to do what they like. Third that private companies should be snubbed. "If local authorities have not power under existing statutes to take up streets and lay wires" power should be given them for this purpose; but the committee "do not consider that the time has yet arrived to give general powers to electric companies to break up streets, unless by consent of the local authorities." That is to say, the enlightened corporations probably possess the power already, and may, if they are so minded, use it; but no electricians need apply. Foreseeing however the possibility of nothing at all being done under these conditions, the Committee throw out a sagacious hint—imported evidently from somewhere north of the Tweed—that "any monopoly given to a private company should be restricted to a short period, with a reversionary right in the municipal authority to purchase the plant and machinery *on easy terms*." Facilities are to be given to any private companies for making preliminary experiments; and no doubt such companies as have a fancy for being "sold" at the finish, on easy terms, will begin operations at once.

The Report, it will be seen, is not encouraging to enterprise; but inventors and promoters need not lose heart. Any sound proposition relating to Electric Lighting will assuredly be considered on its merits and allowed to have fair play, the Select Committee notwithstanding. Its attorney-like suggestions are practically of no more account than its unfavourable remarks about Gas Companies. They are not very popular "establishments;" but it is a somewhat unedifying spectacle to see a Parliamentary body going out of its way to discredit monopolies which Parliament itself has created and upholds. In the words of—we will not say in the *opinion* of—the Select Committee, a special privilege granted to local authorities is "a preference;" granted to private individuals it is "a monopoly," which must, in future, be made to *stand and deliver* directly it has got anything worth plundering. In these days when Corporations, Municipal authorities, Boards of Works, and the like irresponsible and irreclaimable bodies are in worse odour than they ever were, these views would be alarming if they were intended to be acted upon. But it is plain from beginning to end that the committee was "not in a position," and "the time had not arrived" for it to "specifically recommend" anything whatever. It is very learned about science, very virtuous about monopolies, very hazy about the past, and very guarded about the future. 'It would be lamentable," adds the Report, "if there were 'any legislative restrictions calculated to interfere with the development" of electric lighting; and it concludes by expressing a hope that "the Legislature should show its willingness to give all reasonable powers." As there are really no restrictions worth lamenting over, and as the Legislature has not shown the least unwillingness in the matter, persons engaged in developing the Electric Light will do well to pursue the even tenor of their way, treating the whole of the Report as so much Parliamentary pie-crust,—very lightly baked, easily broken, and nothing underneath it.

SS. SCOTIA AND THE WORKS OF THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The Delegates of the International Telegraph Conference and a distinguished party of ladies and gentlemen, at the invitation of Sir D. Gooch (chairman) and the directors of the Telegraph Construction and Maintenance Company, visited on Wednesday, June 25th, the ss. Scotia and the works of the Company.

A special steamer, starting from the pier at Westminster and calling at Blackfriars, conveyed the party to Greenwich. Among those present were the Marquis and Marchioness of Tweeddale, Sir George Elliot, Admiral Sir H. Keppel, Signor d'Amico, Lady Tierney, Sir Henry, Lady and Miss Lefroy, the Hon. M. and Mrs. Ponsonby, Mr. Budde, Count and Countess Reichenbach, General Lüders, Mr., Mdme., and Mdlles. Vinchent, Lord A. Paget, Sir Wm. and Miss Mends, Dr. Brunner v. Wattenwyl, Mr. and Mrs. Pender, Mr. Patey, Count Wimpffen, Miss Bartolucci, Mr. Beer, Mr. and Mrs. Claremont, Sir J. Vogel, Mr. Clark, Miss Manzolino, Mr. Winter, Mr. Tombs, Mr. Griffiths, Mr. and Mrs. Laird, Mr. Clifford, Mr. Curchod, Mr. Salmonovitch, Serpos Effendi and Madame Serpos, Mr. and Mrs. K. Anderson, Mr. Boyce Allen, Mr. Cunningham, Mr. and Mrs. H. Dever, Mr. and Mrs. Otway, Herr Scheffler, M. von Gumbart, Mr. and Miss Erichsen, Mr. Bugge, Mr. Higgins, Mr. Granfeld, Mr. Gibbs, Mr., Mrs., and Miss Binney, Mr. Magalle, Mr. Grant, Mr. Collett, Mr. Temple, Mr. Hesse, Mr. Draper, Mr. Ansell, Dr. Allchin, Mr. Donaldson, Mr. Payton, Mr. Cozens Smith, Mr. T. H. Wells, Mr. Gane, Mr. Muirhead, Mr. A. Campbell, Mr. and Mrs. Campbell, Colonel Champain, Mr. C. Clarke, Mr. Langton, Mr. Guilleaume, Mr. Hocke, Mr. and Mrs. L. Wells, Chev. Berliri, Mr. Salmond, Mr. and Mrs. Burt, Mr. and Miss Gunther, Professor Abel, Mr. and Mrs. Bramston, Sir J. and Lady Anderson, Admiral and Mrs. Hoskins, Miss Overbury, Mr. and Madame St. Martial, Mr. Radoykovitch, Mr. Graves, Mr. Yoshikawa Akimasa, Colonel Osborn, Major and Miss Mallock, Capt. Ommaney, Capt. Evans, Sir G. H., Lady, and Miss Richards, Mr. Steering, M. and Mdme. do Rego, Mr. Nielsen, Captain Suenson, Mr. Round, Mr. and Miss Weaver, Captain and Mrs. Mayne, Mr. Chaytor, Colonel and Mrs. Channer, Mr. Fischer, Admiral Sir Wm. and Lady Hewett, Mr. H. and the Misses Rawson, Mr. and Mrs. Ford, Mr. C. Ponsonby, Mr. Underdown, Mr. Eschbaecher, Mr. and Madame Despecher, Mr. Kara, Mr. Sanger, Mr. and Mrs. Lodge, Mr. J. G. and Mrs. Griffiths, Mr. and Mrs. Shuter, Mr. A. Frey, Mr. de Nordlander, Colonel Crossman, Mr. Benton, Mr. T., Mrs., and Miss Fuller, Mr. and Mrs. Parkinson, Mr. H. Taylor, Mr. W. R. Shuter, Mr. A. Dever, Mr. and Mrs. Jewesbury, Mr. and Mrs. G. W. Elliot, Mr. Robescu, Mr. Richard, Miss Hancock, Mr. and Miss Mathews, Mr. Akerland, Mr. Morice, Mr. and Mrs. Tozer, Major and Mrs. Wood, Mr. Davies, Captain Brownlow, Mr. and Mrs. C. Richards, Captain Halpin, Mr. Rate, M. de Koller, Mr. Benthall, Captain von Hedeman, Stefanaki Bey, Mr. J. Fuller, Mr. Page, Mr. and Miss Willoughby Smith, Mr. F. Beer, Lieut. and Mrs. Channer, Admiral Sir W. King Hall, Colonel Grant, Mr. Honcke, Mr. Preece, Mrs. Phillips, Mr. and Mrs. Stronge, Mr. and Mrs. Donald Currie, Dr. and Madame Lasard, Sir P. Julyan, Sir L. Heath, Baron and Baroness de Stern, Baron and Baroness de Reuter, Sir B. Phillips, Mr. and Mrs. Forster, Mr. W. de la Rue, Mr. and Mrs. Sargeaunt, Miss Dunlop, and Mr. Rawson.

Unfortunately, as the special steamer drew near to Greenwich, the clouds, which had for some time assumed a threatening aspect, poured down a long and heavy shower. Notwithstanding this there was no lack of interest as the party drew near to the Scotia. This splendid steamer, probably the finest cable-laying steamer afloat, was greatly admired, nor did the admiration diminish when inspected in detail, for it was apparent to all that the Company had in the completest manner provided everything that science and experience found necessary in the successful laying of a cable. It is the endeavour of this Company to provide for every possible contingency, and hence it has brought the system of cable laying and repairing to such perfection that a hitch in the procedure is of very exceptional occurrence. Although this is attended with so much success, there is evidently no diminution of caution, and—better than all—nothing is left to chance; but what strikes one most is the *esprit de corps* to be found among those connected with the Company,

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which penetrates among many who are only brought into contact with the works indirectly.

The Scotia, originally a paddle-wheel Cunarder, has been adapted for cable work by Messrs. Laird Brothers, of Birkenhead, and engined by the same firm. The ship is now a twin-screw steamer, fitted with cable tanks, and water ballast tanks, paying-out and picking-up gear of the most approved description, designed by Mr. Clifford, the chief engineer to the Telegraph Construction and Maintenance Company. The Scotia is 430 feet long, 47 feet 8 inches beam, and 38 feet deep. The twin screws are driven by engines indicating 2,600 horse-power. The registered tonnage of the vessel is 3,936 tons, and the gross tonnage is 4,666 tons. There are three cable tanks, having respective capacities of 23,411 cubic feet, 28,902 cubic feet, and 16,128 cubic feet, or a total of 68,441 cubic feet. The quantity of cable that can be coiled in these tanks of course depends altogether upon the kind of cable—whether of a light or heavy type, whether shore-end or deep-sea cable. The water-ballast tanks to be filled with water as the cable is paid out, thus counteracting the loss of weight, have capacities respectively for 215 tons, 140 tons, and 250 tons, or a total of 605 tons.

In the conversion of the Scotia for the work of the Telegraph Construction and Maintenance Company, the ship has by judicious management been considerably strengthened through the manner in which the water and cable tanks have been put into her. The existing arrangements give a double bottom throughout, and she has six water-tight bulkheads running up to the main deck. This, in addition to the water tanks, cable tanks, and the independent tunnels for the screw shafting, renders her an exceedingly safe vessel. She is brig-rigged, with iron masts and yards, giving a large spread of canvass with no unnecessary tophamper. She is fitted with Brown and Harfield's steam windlass and capstan, and, in addition to duplicate hand steering gear, she is provided with Bow Maclaughlin's steam steering apparatus, also with two lighthouses for side lights, in which are placed two of Holmes's lamps, fitted with dioptric lenses.

A modified form of Thomson's pianoforte wire sounding apparatus is fitted up in the vessel, as in all the ships of the Telegraph Construction and Maintenance Company, and the late Atlantic and Indian Cable Expeditions have supplied much valuable information in the way of soundings. She has ten boats, four of which are large metallic lifeboats, all being fitted with air-tight spaces giving a sufficiency of floating power to float with crews on board, the boats being at the same time full of water.

The ship has duplicate picking up gear on the main deck, with only hand gear for working the engines on the upper deck, being the first ship fitted in this way. A great gain is thus obtained in getting a clear working deck, besides keeping the machinery under cover. She has now on board 3,728 tons of cable, coals and stores, with a mean draught of 25 feet, to sail on July 3 for Singapore direct *viâ* the Suez Canal, to lay a portion of the new duplicate Australian cable between Malacca and Singapore, Singapore and Banjoewanjie under the command of Captain Cato. The Seine and other ships will follow shortly with the section of the cable between Banjoewanjie and Port Darwin.

Besides the Scotia, lying off one factory, the visitors noticed the Calabria lying off the other factory of the Company. This ship is taking out a section of the Cape cable.

After luncheon on board the Scotia the larger portion of the visitors landed and were conducted by Mr. H. Clifford and others through the works. The operation of cable making was here seen at its best, as in this particular branch the works can well boast of being the largest and most complete in the world. The copper conductor is covered with its gutta percha coating at the Company's Gutta Percha Works, Wharf-road, City-road, and carried on huge reels, each containing three miles of wire, to Greenwich. These reels are steeped in tanks of water for the purpose of testing the core, which is in the next place covered with cotton tape, to which is superadded a thin brass tape to render it secure against the inroads of the teredo. The next process is to cover it with a taping, saturated with marine glue, and which in its turn is covered with jute. The cable is then passed on to another room, where it is covered with the iron sheathing, coiled in a huge tank, and whitewashed to prevent its sticking. That being done, it is in a state of readiness to be placed on board ship. The electrician's room, fitted up as it is with the best of modern instruments, was a source of wonder, not to say awe, to many of the ladies if not the gentlemen. Mr. Willoughby Smith, the chief electrician of the Company, was assiduous in his efforts to give experimental illustrations of some of the fundamental operations, but whether his audience will do him credit in the future that future must testify. The factory was inspected with great interest by the visitors, who were entertained in the evening at dinner at the Ship Hotel, Greenwich, Sir G. Elliot, Bart., M.P., being in the chair.

After the usual loyal toast had been given and responded to with acclamation,

The CHAIRMAN, in proposing "The Health of the Delegates, coupled with the name of Mr. W. Staring," said that the present Conference was different from the assemblies which generally met under that name. In the present case gentlemen of high position in their respective countries had met not only to confer and discuss, but to take decisions, which had the force of laws, from which there was no appeal. The Telegraphic Parliament was the only instance in which the great ideal of a systematic settlement of international differences had been carried into effect. The International Bureau at Berne was like a supreme court, where, during three years, every Government that had a complaint to make, or a reform to recommend, lodged its case, and from these international headquarters of telegraphy timely notice was given to all parties, so that when the Conference met every third year every delegate had acquired beforehand a full knowledge of the great questions which would then have to be settled. In practice it had been proved that every triennial meeting there was plenty of work—and important work—to be done; and this was not to be wondered at when it was considered how great were the strides that telegraphy made year by year. Since the last Conference duplex and quadruplex telegraphy had become an accomplished fact; underground lines had been laid to a large extent, and the amount of traffic over land and submarine lines showed an extraordinary growth. All these were elements which would enable the boon of telegraphic intercourse to be extended, and the tariffs to be reduced [hear, hear]. It was to be remarked, to the honour of the Governments, that the telegraph was not to be treated as a branch of the fiscal system. All that was asked in the different countries of Europe was that the telegraph should be self supporting, and whenever there was a surplus that excess of revenue was employed in establishing new lines and opening new stations. It was a matter of congratulation that in all reforms the Conference had taken the initiative. In this country we generally waited till there was an outcry against some evil, or a loud demand for a change or remission of burdens; but in the case of telegraphy, although there was an occasional grumble, the public had never yet found it necessary to complain or remonstrate, because the enlightened and practical men who were their guests had never said "Let us rest and be thankful," but they had taken the lead and given the public the benefit of their experience and liberal minds [hear, hear]. It was to be hoped that their visitors had been pleased with what they had seen that day. Their works were the cradle of submarine telegraphy Of the 70,000 miles of cable laid, this Company had laid 55,000. With the interest that Company had in cable enterprize he might, perhaps, be allowed to suggest that the delegates might well before separating consider the great subject of the neutrality of cables in time of war. Any wilful interruption of a long cable in war, on account of its international character, was sure to do as much injury to the commerce of a friendly nation as to the enemy for the time being. The telegraph—which had brought nations into closer relations, developed commerce, and done so much for the education of the people by diffusing through the Press every morning the most interesting intelligence from the remotest regions—was well entitled to that recognition of being a beneficial and civilising influence, which a declaration of neutrality in time of war would stamp upon it [cheers]

Mr. STARING, in reply to the Chairman's toast, said:—Gentlemen, I willingly accept the position of spokesman on behalf of my colleagues the members of the Telegraphic Conference of London in order to express our gratitude for the kind and cordial words the president has just addressed to us. Reunions such as this at which we are now present—so perfectly organised and splendidly carried out by the Committee—do much to cultivate friendly feelings in the members of the Conference, and to augment that spirit of conciliation and goodwill whic was exhibited in the former conferences, and which is so indispensable in order to arrive at results satisfactory to the administrations as well as to the public. These reunions have quite a special interest for us when their object is to visit some great establishment of particular importance to telegraphy, such as the vessel that we have examined and the workshops that we have traversed to-day. This visit has allowed us to see and to admire afresh the means by which British genius and industry have succeeded in overcoming the obstacles which until latterly have opposed the union of all the continents in a single telegraphic network. And thus I think I am giving expression to the wish that every one of us must have felt whilst realising the efforts which have been needed to surmount difficulties which at first were thought to be insuperable—a wish for the ever-increasing prosperity and success of British industry.

Mr. J. PENDER, M.P., proposed "The Prosperity of the Telegraph Construction and Maintenance Company." He was

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sure that all present would join heartily in the toast he proposed. They were enjoying the splendid hospitality of the Company; they had visited the works and seen science and art combined in the manufacture, such as could not be witnessed in any other part of the world. The telegraph was the great civiliser—almost all commercial transactions required its aid. The Telegraph Construction and Maintenance Company had given a great impetus to telegraph construction; but they must recognise the labours given to the work by Sir G. Elliot, who was a pioneer in the work before the Company was formed. Submarine telegraphy was greatly indebted to him. The greater part of the 70,000 miles of cable had been made by this Company, and he could not help thinking that such work was the great promoter of peace and goodwill among men. He felt that the bringing together of strangers face to face under such auspices as those under which they assembled, would enlarge their sympathies, and that the results would ultimately conduce to a better understanding among the nations [great applause].

Sir G. ELLIOT, in a brief but warm and hearty speech, replied: He tendered his warmest thanks for the kind manner in which they had welcomed the toast. He must say, however, that Mr. J. Pender had much more to do with the development of telegraphy since the year 1864 than any other living man. Mr. Pender had referred to his early labours; he would remark that in Greenwich the telegraph was first cradled, and that he had been one of the nurses. In 1864 the firm to which he belonged grew too large to be managed by a few, and the Telegraph Construction and Maintenance was founded, the result being the works they had visited that day [cheers]. The power and usefulness of the telegraph can hardly be imagined, much less described; it assists in telling what is wanted, and assists in doing what is wanted; it is utilised on every hand, and its success is proverbial [cheers]. In conclusion he would propose, "The Guests of the Evening."

Count WIMPFFEN replied: He assured them that they all felt happy to ascertain the heartiness and the grandeur of British hospitality, which surpassed all their expectations, and he could only reply to their welcome by emphasising the words used at another meeting by his friend, M. Vinchent, and say, "Old England for ever" [great applause].

Signor D'AMICO, in a very humorous speech, spoken in French, which received constant applause, as hit after hit was made, proposed "The Ladies."

Lord ALFRED PAGET briefly replied, and the company departed to the special train provided for their return to town.

A selection of instrumental music was performed during dinner, and some vocal music was interspersed among the proceedings of the evening, under Mr. W. Ganz as conductor.

CORRESPONDENCE.

DUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although I do not share Mr. Stearns' aversion to the publication of the correspondence on this subject in your journal, I have no desire to increase his discomfort by prolonging the discussion.

The letters of April and May, 1878, show most clearly that Mr. Stearns refused my challenge to take proceedings to support his patents.

The offer was distinctly made to admit not only the making but the user of the apparatus within the jurisdiction of the English Courts. Mr. Stearns, however, in the "exercise of his discretion," as his solicitors express it, waited fifteen months before taking action, during which time, as I am informed, he was laboriously striving to make his invention work at Valentia. By what means he has at length succeeded there is as yet unknown, and any information on the subject is refused.—Yours, &c., J. MUIRHEAD, JUN.

Westminster, July 3, 1879.

LECHLANCHE CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have two Lechlanché batteries which I am about to lay idle for a long time. Will you kindly tell me in *The Electrician* whether I had better withdraw the zincs with the cells from the jars, and let the cells become dry, or let them remain as they are, or can you suggest any other course?—Yours, &c.,

Torr Grove, near Plymouth, 26th June, 1879. B.

TELEGRAPHS IN CHINA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in the *North China Herald* for the 29th April, an assertion said to be copied from the *Telegraphic Journal*, "that the *first* telegraph line to be opened for *public correspondence* in China is now in construction between Tientsin and Taku, a distance of about thirty miles," &c.

Permit me, through the medium of your columns, to correct the error into which your contemporary seems to have fallen. The line now "in construction"—and it has been so for a little over three years, according to the newspapers—is not the *first* but the *fourth* telegraph line in China opened for public correspondence. The three older lines were built and opened as follows:—

1. Between Shanghai and Woosung, a distance of about ten miles, built by the Great Northern Telegraph Company, and opened for public correspondence in September, 1873. This line is still working, and carries three wires, two for the Company's cables and one local wire.

2. Between Foochow and Pagoda Anchorage, a distance of a little over eight miles, built by the same Company, and opened for public correspondence in July, 1874. This line was sold to the Chinese Government a year later, and has since been worked by native operators trained by the Company. It is in operation still, and has been open to the public all through its existence.

3. Between Taimanfoo and Takao au Formosa, a distance of nearly thirty miles, built in the summer of 1877 by native engineers, and worked by native operators trained by the Company. This line was opened for public correspondence somewhere in September, 1877, and has been so ever since.

I am, of course, only taking into account *overland lines*, to which I suppose your contemporary refers, as it is well known that the Great Northern Company has connected the ports of Shanghai, Amoy, and Hong Kong with cables since 1871.—Yours, &c., J. HENNINGSEN, Superintendent, Great Northern Telegraph Co.

Amoy, 14th May, 1879.

TESTING IRON AND STEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observe at page 50, col. 2, of your present volume you quote from *The Times* a paragraph in which the genius who does the scientific gush for that journal yields up to Mr. Herring (an *American* mining engineer) the credit of applying electro-magnetism to discovering the flaws in iron and steel.

Now, *let honour be given where honour is due*, say I. Our American cousins seem to have cultivated the knack of laying claim to inventions and applications which have been the property of the scientific world for years past; and it is curious to observe how self assertion of this kind carries the would-be-thought scientific journalist away with it.

If your readers will refer to pages 359, 360, and 361 of Professor Pepper's "Cyclopœdic Science Simplified" they will find there quoted a report by Mr. Paget, C.E., of an undoubted discovery by Mr. S. M. Saxby, R.N., of the applicability of the magnet to the purposes for which *The Times* tamely yields up the credit to Mr. Herring.

Mr. Saxby (by the permission of the British Admiralty Board) tested his discovery years ago in the Royal Dockyards of Sheerness and Chatham and met with great success. At any rate, it seems to be an indubitable fact *that Mr. Saxby ought to have the credit of priority of discovery and application of the magnetic test for discovering the flaws in iron and steel.*—Yours, &c.,

P. H. FOWELL-WATTS, LL.D.

6, South-square, Gray's Inn, 27th June, 1879.

AMALGAMATED ZINC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be glad if you or some of your readers will explain clearly and simply the effects of amalgamation, and the laws which regulate these effects.—Yours, &c, A STUDENT.

THE OPTICAL DIVISIBILITY OF THE ELECTRIC LIGHT.

An ingenious notion, which on more than one occasion we have heard discussed in this country, has with characteristic promptitude been brought in America out o the domain of suggestion, and more or less into that of practice. We refer to the

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system of virtually subdividing the electric light by combinations of lenses and reflectors which has been devised and brought forward by Messrs. Molera and Cebrian, civil engineers, of San Francisco, and which is described and illustrated in the *Scientific American* of June 21. In this system, a single electric lamp placed near the current generator supplies light for a building or a street. This lamp is surrounded by a system of lenses and reflectors forming a chamber of light. These lenses concentrate the whole of the light into as many beams of parallel rays as there are faces in the chamber. In this form the light may be projected through long distances. The intensity of the light when not condensed is inversely proportional to the square of the distance from the source of light, but when the light is projected in parallel rays and is prevented from radiating, its intensity remains unchanged, except perhaps a small loss by the absorption of the atmosphere. From every face of the chamber of light a box or pipe projects, which encloses the light beam. These pipes are laid along the streets, and along the walls and floors of buildings. At every side street a smaller pipe branches out of the main one, and at their junction there is a reflector, which, by its size and position, will divert into the side street any desired percentage of the entire light. By means of this device, every street in a city may be provided with one or more pipes carrying a certain amount of light that is always controllable by merely changing the position of the reflectors. This arrangement may be compared to valves and water gates of a system of water distribution.

In carrying out this bold design, the commercial feasibility of which cannot safely, at the present moment, be either affirmed or denied, the inventors employ the polyzonal lenses of Fresnel, instead of reflectors, in the faces of the "chamber of light;" whilst at every angle in the pipes or longitudinal boxes they place either a reflector or a totally-refracting prism; and at the terminations of the tubes they have lenses for the distribution of the light in the rooms to be illuminated, these lenses being adjustable so as to diverge the light more or less according to requirements.

As to economical advantages it will be noticed that regulators or lamps are entirely dispensed with, and that attendance is consequently not required. Another important feature is that a large generator of electricity may be employed, thereby greatly reducing the cost of the production of the electrical current. The loss consequent upon the use of electrical conductors is entirely avoided, as the single lamp needed is located near the generator, permitting of the use of a short and thick conductor having but small electrical resistance. Messrs. Molera and Cebrian exhibit some very flattering figures based upon an expenditure of twenty horse-power, which, as we have already learned, is not sufficient to obtain the most advantageous results. They claim that they are able to produce by their system 195 lights per horse-power, giving a light equivalent to 1,958 candles, and that the cost of lighting is less than one-twentieth the cost of gas.

The intention is here much in advance of some important steps which have been taken, by M. Pulvermacher and also by M. Liebert, to distribute the light from a single focus, by means of surfaces of platinised glass, which partly reflect and partly transmit the luminous rays, and corrugated or embossed glasses acting as refractors. But, on the other hand, the endeavours now referred to appear to have resulted in a measure of success which is no longer problematical. The properties of platinised glass are undoubtedly valuable in relation to the object in view; and, as these properties are by no means generally known, we may here briefly allude to them. The ordinary method of shading the electric light, by means of ground or opalescent glass, whilst it protects the eye from the unbearably dazzling effect, is one of the best possible illustrations of the process of "putting a light under a bushel." Thus Sir J. W. Bazalgette and Mr. T. W. Keates, in their recent report on the Thames embankment lights, state that the loss of light produced by opal glass was 59 per cent.; whilst that produced by frosted glass was *only* 29·9 per cent. Now a suitably platinised plate of glass will shade the light by allowing only a certain percentage of the luminous rays to be transmitted through it; but the remaining portion of these rays, instead of being absorbed and totally lost, will be reflected almost without loss from the metallised surface. The most advantageous mode of disposing of these reflected rays is a problem of considerable interest, the conditions of which vary according to circumstances; but, either in an enclosed space or in the open air, an effect which is equally pleasing and advantageous may be obtained by the use of these partly transparent reflectors. We have observed with great interest the new departures which have been made, from an economical starting-point, in the direction of a solution of the important problem of utilising to the best advantage the electric light, as now produced by our improved magneto-electric and dynamo-electric machines, in conjunction with the various improved forms of the electric lamp; and we hope soon to have occasion to revert to the present subject.

EDISON'S ELECTRIC LIGHT.

On Saturday, June 28, Mr. Edison's London patent agents, Messrs. Brewer and Jensen, of 33, Chancery-lane, filed the final specification for his third English patent on the subject of the electric light. The patent is for "Improvement in means for developing magnetism and electric currents and in apparatus for illuminating by electricity." Thus far it is the most important patent relative to Mr. Edison's researches on the subject of the electric light that has yet appeared.

One part of the specification relates to an electric lamp or burner, made of platinum, platinum-iridium alloy, or other metal which fuses at a high temperature. This wire or strip is coated with an oxide of metal, such as cerium zirconium, calcium, magnesium, or other metal or material which will not be injured by a high degree of heat. The effect of this coating is called "pyroinsulation." The wire or strip may be pyroinsulated by dissolving the oxide in an acid, coating the wire or strip with the solution, and then passing the wire or strip through heat from a flame or otherwise, to decompose the solution and cause the deposit of the oxide upon the wire or strip.

If the burner is made of wire, the latter after being pyroinsulated is wound upon a spool or cylinder of lime, or other infusible material, and when the burner is placed in an electric circuit and the circuit closed, the electricity passes through the entire length of the wire of the burner and brings it to incandescence. The metallic oxide forms a pyroinsulating coating which protects the metal of the wire so as to render it more difficult to fuse, at the same time preventing the electric current passing from one coil to the next, thereby compelling the current to travel the entire length of the wire. If the burner is made from a strip of metal, the same should be thicker at one edge than the other, so that it may be rolled to an uniform thickness at the same time that it is coiled into a spiral. The strip of metal should be thin, so as to obtain considerable length in a short spiral. The spiral or helix thus made is pyroinsulated as aforesaid, and then compressed into a compact cylindrical form. Sometimes the pyroinsulating material is placed as a layer between the coils of the spiral or helix.

The thermal regulators set forth in "Edison's" British patent of October 23, 1878, may be used for regulating the current to burners made of a wire or strip of metal, coated with a pyroinsulating material for the purposes aforesaid. This pyroinsulating coating allows of very fine wire being used for the burner. Hence several layers of the wire may be wound upon the spool of infusible material, and the burner will have a resistance of several hundred ohms, which permits of several hundred burners or lamps being connected quantitatively in multiple arc, without requiring large main conductors.

In some instances a burner or candle is made of finely-divided iridium, or other metal not easily fused, mixed with an oxide of titanium, iron, or other metal, which acts as a conductor when highly heated. This is to be moulded into the desired form, and by properly proportioning the mixture the current to the burner is regulated by the heat of the said burner, the resistance being lessened in proportion to the heat.

Another feature of this invention relates to the arrangement of the main conducting wires, so as to obtain a complete metallic circuit and at the same time take advantage of the conductivity of the earth so that the mass of metal in one of the conductors may be reduced. The earth and metallic conductor serve at the same time as a protection for the insulated conductors.

The magneto-electric machines may be of any suitable character and driven by power. They may be arranged between two main conductors in ranges or multiple arcs of three, four, or more in each, and the connections should be for intensity. One is a tube laid in the earth, and preferably of iron, and it forms, together with the earth, one half of the circuit; within this tube is the other, viz., an insulated conductor, preferably of a number of strands of copper twisted together in the form of a cable, one strand of the cable being dropped, say every hundred feet, so that at the extreme end of the circuit there shall be but a single strand. This cable is insulated from the tube by any cheap or economical insulation, such as tar or asphaltum. A branch tube containing a single strand from the cable is to enter each house or building, and from the basement smaller wires are run to the various parts of the house where the lights are required. Each lamp is to be provided with a switch, so that it may be disconnected from the conducting wires.

The electric generators at the central station are provided

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with constant field-of-force magnets, the helices of which are in the electric circuit. Hence if all the lamps feeding from the main conductors are disconnected by their switches, the circuit will be broken, and no current passes through the conductors leading from the station to the lights. Hence the steam engine driving the magneto machines runs lightly, and with the expenditure of a very small amount of force. If now the switch of a single lamp is turned, the lamp is connected to the branch wires from the main conductors, the circuit is closed, and only sufficient current passes from the central station to supply that lamp, because the external resistance determines the amount of current.

In this way the current will be proportioned to the number of lamps in the circuit. Each lamp is preferred to contain a resistance, when incandescent, of 1,000 ohms. As before described, the connecting of one or more lamps causes a sufficient amount of current to be developed at the central station to keep the same incandescent. It follows that if the machines at the station are arranged expressly for tension and quantity, many hundreds of lamps may be placed in circuit between the main conductors, the reduction of resistance upon placing each lamp in circuit drawing the proper quantity of current from the station. Hence the greatest economy possible is obtained by causing all the resistance outside of the main conductors to be light-giving resistances.

Another part of the invention relates to means for storing the electric current or energy, so that the same may be used as required. This is effected by the use of secondary batteries, and there are devices described for shifting the current from one secondary battery to another periodically, so that one may be in use while the other is being charged from the main circuit.

The following are the "claims":—

First. An electric lamp or burner made of a wire or strip of metal coated with pyroinsulating material, substantially as and for the purposes specified.

Second. The electric lamp or burner made of layers of metal with intervening pyroinsulation substantially as specified.

Third. In combination with a burner formed of pyroinsulated metal, a metal case surrounding the burner, and made incandescent by the heat thereof substantially as specified.

Fourth. The method of pyroinsulating the wire or strip of metal for the conductor, consisting in passing the wire or strip through a solution of lime, magnesia, or similar material, and then through heat from a flame to effect decomposition of the solution as specified.

Fifth. The insulated metallic conductors within a metallic case which forms with the earth the return circuit substantially as specified.

Sixth. The combination with electric lamps and a main circuit of two secondary batteries, and circuit connections and switch substantially as set forth to alternately change the main and secondary circuits substantially as specified.

Seventh. The combination with a secondary battery and its enclosing case of a diaphragm, or similar device, acted upon by the accumulation of gas pressure, and a switch or lever moved by such diaphragm to disconnect the main circuit from the secondary battery substantially as set forth.

Eighth. An electro-magnet in the same circuit as the lamps or burners in combination with an armature lever, latch, and contact piece substantially as and for the purposes set forth.

One sheet of drawings accompanies the specification, and there are ten figures in illustration of the invention on the sheet.

RECENT PATENTS.

3738. Ships' Compasses, &c., *C. D. Abel.—Dated* 31*st September*, 1878.—(*A communication.*) 8*d*.

This consists in a means of increasing the mean directive force of ships' compasses by the application thereto of relatively small masses of soft iron free from permanent magnetism, without thereby affecting the deviations resulting from the locality where the compass is placed.

3801. Signalling by Electricity, *E. B. Bright.—Dated* 26*th September*, 1878. 6*d*.

This consists in the employment of electrical measures of resistance placed in posts or boxes fixed in streets or buildings, whereby a warning of fire or a call of any kind is given by a finger key, connecting plug, or push knob, or other convenient means of making or breaking or varying an electrical circuit or circuits. By this means the locality of the warning or call is indicated by balancing the electrical resistance of the conducting wire in combination with such electrical measures of resistance, by the use of differential coils connected to the apparatus at the fire station or the place where the call is given, which is furnished with corresponding electrical measures of resistance.

3856. Marine Torpedoes, *B. J. B. Mills.—Dated* 30*th September*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d*.

A magnetic appliance is adapted to torpedoes, by means of which they will attach themselves to an iron vessel.

3916. Microphonic Speaking Apparatus, *C. F. Varey.—Dated* 4*th October*, 1878.—(*Void.*) 2*d*.

In order to transmit spoken words to a distance through a telegraphic line wire, an instrument similar to a microphone is employed, the instrument being enclosed in a case so as to protect it from all disturbing vibrations. The instrument with its case is supported upon a base, within which a dry pile is enclosed.

3923. Construction of Electro-magnetic Letter-indicating and Type-printing Telegraph Instruments, *W. E. Irish.—Dated* 5*th October*, 1878. 6*d*.

This consists in the combination in such apparatus of a series of keys representing signs or ciphers required to be transmitted in suitable connection (either directly or indirectly) with a series of stop pins, by means of which a rapidly rotating arm actuated during the transmission of a message by the line current, and by means of the armature of an electro-magnet, can be arrested at any part of its motion, whereby the line current is broken, and the similar and synchronously rotating arms of all instruments in circuit are consequently arrested in a similar position; and the further combination with such apparatus of a pointer and dial, so that the letter or other sign or cipher sent is indicated (at the receiving station) by the former on the latter; and the further (optional) combination with such apparatus of a type wheel in connection with an inking well and a hammer or marker pad, by which, if required, the letter or other sign or cipher thus transmitted and indicated may be also printed on a traversing slip of paper intermittently drawn forward (at the receiving station) by the agency of a local circuit, by which also the hammer or marker pad is actuated when required.

3924. Electrical Apparatus for Telegraphic and similar Purposes, *S. F. Van Choate.—Dated* 5*th October*, 1878. 8*d*.

This relates to improvements on patent No. 156, dated 19th January 1865, and consists of a line or cable divided into two or more stretches, lengths, or sections, united and operated by means of a globe instrument, or similar apparatus in connection with self-adjusting magnets enclosed and hermetically sealed therein or otherwise arranged, and with vibrators, helices, and suitable connections, and electrical and magnetised polarities and powers.

3960. Telegraphic Transmitting, Receiving, and Call Apparatus, *J. F. Bailey.—Dated* 8*th October*, 1878. 6*d*.

The instrument works without battery by induction produced by the rapid separation of an armature from the poles of a magnet. It can serve both as a transmitter and a receiver, and contains two armatures, one moved by the operator when desired to produce an electric current in the line, and the other under the influence of currents passing through the line makes a corresponding signal, either by striking upon a bell or otherwise. The same magnet and bobbins serve for both armatures.

3971. Connecting the Ends of Wire for Continuous Fencing, Electric Telegraphs, &c., *G. and E. Woods.—Dated* 9*th October*, 1878. 6*d*.

The two ends to be joined are inserted between two surfaces of a connecting piece, which are made to approach each other and nip the ends to prevent them being withdrawn. According to one mode, the ends are placed between two semi-circular shaped pieces provided with an external screw thread, the two surfaces being brought together by means of nuts. Several modifications are shown.

3976. Magneto-electric Machines, *M. R. Ward.—Dated* 9*th October*, 1878. 6*d*.

Grooves are provided in the cylindrical core of the armature to receive the coils of covered wire, and when the armature is wound the coils fill these grooves, so that the wound armature is approximately cylindrical. When this armature is mounted in the machine the portions of the core between the coils are only separated from the pole pieces of the electro-magnetic inductors by a clearance sufficient to avoid risk of actual contact when the machine is in use. In place of forming the core of a single piece it is built up of bars nearly of H form, but with the sides somewhat inclined, and a number of these bars placed side by side form the grooved cylindrical core.

3985. Electric Lighting, *H. W. Tyler.—Dated* 9*th October*, 1878.—(*Not proceeded with.*) 2*d*.

This consists in the application of platinum or any other suitable material to admit the passage of continuous currents at the same time that light is evolved. Also in a contrivance for regulating the passage of the currents, consisting of a cylinder, switch, or other form of commutator, capable of adjustment to admit of the passage of the currents in different directions. This contrivance is provided with voltaic connections so arranged that the current may by its action be turned either through the light evolving apparatus or past it without passing through it, and also when desired, with resistance coils to admit of the current being made to pass partially through it and partially past it in different degrees.

TRAFFIC RECEIPTS FOR JUNE, 1879.

Companies.	June 1879.	June 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company....................	—	—	—	—
Cuba Submarine Company..........................	2,400	3,175	—	775
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company ...	15,000	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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Companies.	Closing Prices July 2.	Business Done Week Ending July 2. Highest.	Lowest.
Anglo-American	54½, 5	55	54¾
Do. "B"	84½, ¾	85⅛	84¾
Do. "A"	26½, 7	27¼	26⅞
Brazilian ex div.	6¾, 7	6⅞	6⅞
Cuba	8½, ¾	8⅝	8⅝
Do. Ten per Cent. Preference	16, 17	—	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	10¾, 11¼	—	—
Direct United States	10¾, ¾	10½	10½
Eastern	7 11-16, 13-16	7 13-16	7 13-16
Do. Six per Cent. Debenture	104, 107	106½	105
Do. Five per Cent. do.	102, 104	—	—
Do. Six per Cent. Preference	11 13-16, 15-16	11⅞	11⅞
Eastern Extension	7 11-16, 13-16	7¾	7¾
Do. Six per Cent. Debenture	103, 111	108½	108½
German Union	7¾, 8¼	7 13-16	7 13-16
Globe Telegraph and Trust	4¾, ⅞	4⅞	4⅞
Do. Six per Cent. Preference	10 11-16, 13-16	10⅞	10⅞
Great Northern ex div.	8½, ¾	8¾	8 5-16
Indo-European	20½, 21½	—	—
Mediterranean Extension	2½, 3	—	—
Do. Eight per Cent. Preference	8¾, 9¼	—	—
Reuter's	9, 10	—	—
Submarine	225, 235	—	—
West India and Panama	1½, ¾	1⅝	1⅝
Do. Six per Cent. Preference	7¾, 8¼	8	8
Western and Brazilian	3⅝, ⅞	—	—
West. Union Seven per Ct. 1st Mt.	115, 120	—	—
Do. Six per Cent. Sterling	105, 107	—	—

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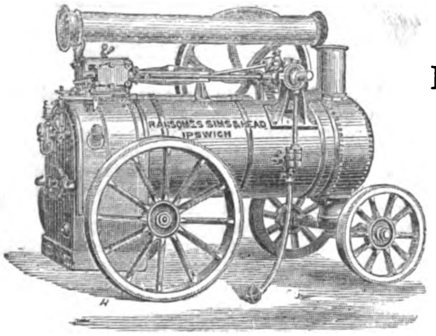
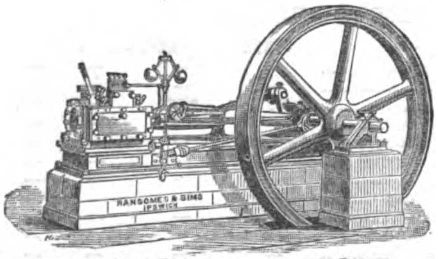


PORTABLE STEAM ENGINE.



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NOTES.

THE CAPE CABLE.—The Telegraph Construction and Maintenance Company's steamer Calabria, having on board the Zanzibar-Mozambique section of the South African Cable, sailed from the Thames on Thursday, July 10th.

AUSTRALIAN DUPLICATE CABLE.—The steamship Scotia—the ship visited by the Delegates of the International Telegraph Conference on Wednesday, June 25th—has passed Gibraltar on her voyage to lay a portion of the Australian duplicate cable.

GAS v. ELECTRICITY.—In an article on Gas Manufacture, the *Gas Trade Circular* admits that the electric light has given a grand impetus to the manufacture of gas throughout the kingdom. The present systems of electric lighting are not feared, but "it is the future of the electric light that has to be guarded against." Our contemporary, writing somewhat in favour of *employés*, points out that the directors of the various companies should appreciate and duly reward the scientific men and the inventors that are working to improve the manufacture of gas, and leading to still further economy. Hitherto talent has been at a discount, but as soon as existence is threatened talent is to be petted and promised rewards; at any rate, we have frequently found that the rewards end with promises, and the tangible results accruing to talent are, like will-of-the-wisp—hardly ever to be caught. We heartily trust the directors of gas companies may even through fear be taught a lesson which will not be forgotten in a time of seeming security.

ELECTRIC LIGHTING.—According to the invention of Sir H. W. Tyler, of Wyvenhoe Hall, Colchester, he employs for the purpose of electric lighting a substance such as carbon, platinum, or other material or combination of materials, which, in offering a certain resistance to the passage of the electric current, however produced, becomes heated so as to give out heat or light, and these substances or combination of substances he encloses within another substance or combination of substances, constituting a casing of a refractory nature, such as German glass, rock crystal, glaze, fire clay, or steatite, which shall either be sufficiently transparent to allow of the light of the incandescent charcoal or other substance passing through them, or shall themselves be rendered incandescent by the heat of the interior substance, and shall thus constitute the means of affording light. By such refractory outer casing the carbon or other material forming the conductor is prevented from burning away or being destroyed, while it allows of the passage of a continuous current, and facilitates the employment of a greater number of lights on one circuit than heretofore.

ELECTRIC LIGHTING.—A Select Committee of the House of Commons, of which Mr. A. Pell was chairman, on Thursday concluded their consideration of the Bill promoted by the Liverpool Corporation to give power to adopt and supply, for public and private purposes, lighting by electricity. It was on the second reading of this Bill that the House decided to appoint a Committee on the general question of allowing the introduction of electric lighting for public purposes, and to suspend this and numerous other Bills of the same kind until the Committee had reported. The report published a short time ago was, on the whole, encouraging; but it left open to doubt certain points which might create serious difficulty if any Corporation adopted electric lighting by virtue of their existing powers under the Public Health Act. The Liverpool Corporation therefore resolved to proceed with their Bill, in order to secure full and distinct legislative powers, and this Bill came before the Committee this week. It originally asked for powers not only to supply electric lighting, but to buy up the existing Liverpool Gas Light Company, and to raise £50,000 for the purposes of the Act. The second proposal was subsequently dropped, but the Gas Company petitioned against the Bill, and were strongly represented by counsel—Mr. Aspinall, Q.C., Mr. Bidder, Q.C., and Mr. Michael, Q.C. No other petitions of any importance were lodged. The Corporation were represented by Sir E. Beckett, Q.C., Mr. Pope, Q.C., and Mr. R. S. Wright, who put before the Committee strong local evidence in support of the Bill, and also called Dr. Siemens in their favour. The Gas Company did not give evidence, Mr. Aspinall simply arguing against the proposed scheme. The Committee at once intimated their decision to pass the Bill if amendments were made in the preamble the effect of which would be to limit the power of the Corporation to the making of a scientific experiment, and not allow them to make it a commercial undertaking for purposes of profit or to compete with the Gas Company. Amendments were proposed by the Corporation in this direction, and the Committee passed the Bill.

ELECTRIC LIGHTING IN AMERICA.—A recent number of the *New York Times* reviews at considerable length all the systems of electric lighting at present before the public. It gives the preference to the American inventions, and the results obtained by some of these are spoken of as being quite remarkable. It appears that in the Equitable building, New York, two Maxim electric lamps give three times the light that was given by fifty-one gas-burners, at a cost of 11 cents per hour, against 45 cents for gas. One large establishment on the Bowery has replaced 75 gas burners by four electric lamps at half the cost. Light for light, as calculated from reliable data, the cost of electrical illumination as compared with gas stands in the proportion of one to six. There remains no doubt in the mind of our American contemporary from a collation of the two hundred or more instances in the new country in which Brush, Maxim, or Fuller generators and lamps are in operation, that for large spaces the electric light can be supplied "for from one-eighth to one-tenth of the present cost of gas." It is stated that in one of the manufactories now using electric illumination in place of gas, the cost of lighting the three floors is 10½ cents an hour. When this company used gas their bills for much less light averaged one dollar per hour. The result of a full survey of the field shows four electric lamps claiming to meet the conditions of subdivision—namely, Edison's, Holcombe's, Werdermann's, and Fuller's, with one comprehensive method of subdivision (D'Ivernois'), and one double-circuit generator, that of Mr. Keith. "It is manifest (says *The Times*) that the gas companies have been driven from every stronghold, except that of purely domestic lighting, and that they may be driven from that before the year 1879 closes." Madison-square-gardens, N.Y., *The Times* announces, is to be lighted by means of four electric lamps of the Fuller patent, for a term of three months, each of 2,500 candle-power, for three and a-half hours per night, at a cost of about eight dollars to the proprietor of the place. This, it appears

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will be about one-fourth the present cost of lighting the garden by gas, with from three to four times the illuminating power of the gas. "It is a curious fact (says *The Times*) that, intense as the heat of the electric arc is at the point of the positive electrode, it radiates scarcely one-tenth the amount of heat as the same power of gaslight. While, for instance, the arc will reduce the point of a knife to vapour almost instantaneously when placed at the point of the positive carbon, one can light a cigarette at the blaze without a sensation of heat in the hand. The lack of radiant heat is believed to be one of the great advantages of the electric light for summer-night resorts, and the illumination of Madison-square-gardens will be the first extremely favourable test of electricity for popular uses."

The Microphone in Australia.—We extract the following from the *Journal of the Telegraph Electrical Society*, Melbourne:—"At the usual monthly meeting, at the Melbourne Athenæum, on Wednesday, 2nd April, Mr. J. E. Edwards produced a form of microphone, which he considered gave very good results. In this instance a small piece of carbon being fixed to the baseboard, another pencil of carbon is suspended like a pendulum above it, the end carbon pendulum being allowed to rest lightly against the piece on the baseboard. Each of these carbons being then connected with the line wire, in whose circuit was included a telephone and a battery, the microphone was tested in various ways, and found to be remarkably sensitive. Indeed, this sensitiveness of the microphone to all sounds is a serious drawback to its utility. This was exemplified, for instance, on this occasion. Mr. Gillbee, the well known surgeon, being present, wished to hear by the microphone the action of the human heart, but was quite unable to do so with anything like satisfaction, owing to the additional noise produced by the breathing of the person experimented on, and the consequent movement and friction of the microphone against the patient's body, which almost overpowered the noise of the heart's action. The battery which Mr. Edwards used to experiment with this microphone deserves a passing notice. It consisted simply of a piece of carbon about three inches in length, and of the thickness of an ordinary pencil; round this was placed a small quantity of sulphate of mercury, a piece of calico was wrapped round this (acting as a porous cell); and a piece of zinc three or four inches by two inches enclosed the whole. When moistened with a little water, this minute battery worked very satisfactorily, and Mr. Edwards remarked, would keep very constant for two or three months. Mr. P. R. Challen mentioned that among various forms of microphones with which he had experimented was one in which the battery was comprised within itself, being constructed thus:—"A plate of zinc formed the base, upon which was laid a plate of carbon carrying an upright wooden stud, on the top of which another strip of carbon was firmly screwed; this strip was perforated so as to admit of the insertion of a pencil-shaped piece of carbon which, when placed in position, made contact between the upper carbon strip and the bottom carbon plate; the circuit is completed by attaching the line wires to the zinc plate and the upper carbon strip. This form has been found to give splendid results, combining as it does portability and compactness. Under ordinary circumstances the mere contact of the carbon and zinc give sufficient current, but for long distances it is necessary to place moistened blotting paper between the two, the paper being moistened either with a saline or acid solution. Mr. Challen also mentioned that he had made some successful experiments with a form of microphone as a substitute for the stethoscope, which he proposed to place before the society at a future meeting."

Electro Deposition of Metals.—Several important improvements in dynamo-electric machines that may be used for all purposes for which such machines are now employed have been invented by Mr. G. Zanni, of Highbury, and he provides apparatus specially applicable for the electro deposition of metals, whereby he is enabled to regulate with great ease and simplicity the strength or depositing power of the current in the bath, according to the number or size of the articles to be covered, thus ensuring an equally good effect under varying circumstances—a result very difficult to obtain with the machines and appliances heretofore used. He constructs the machine with a series of stationary electro-magnets, each composed of a soft iron core surrounded by wire coils, and placed within a metal—by preference case-hardened steel—frame. The soft iron cores are hollow, to provide for the passage of a current of cold water through them to keep them cool. The electro-magnets thus formed are attached to the interior circumference of the case of the machine, being arranged in circular order. The rotary coil of the machine is composed of a soft iron ring made in segments, and around each of these segments he winds a quantity of insulated copper wire. The ring is attached to the shaft of the machine, and revolves within the circle formed by the stationary magnets. The segments of the ring are formed with tongues and grooves, so that they may be readily attached to or detached from each other. The advantage gained by so constructing the ring is that the coiling of the wire around the same is more readily effected than with a continuous ring, and the wire may be coiled more tightly and uniformly. In order to provide means for regulating the strength of current in the bath when using the machine for electro deposition, he provides a resistance apparatus. Around a bar of ebonite, or other suitable non-conducting material, he coils naked or uncovered German silver wire, and the coil thus formed is so arranged and placed in the circuit that by operating a key or lever provided for the purpose, and in connection with the said coil, he can cause the current to take a longer or a shorter path through the resistance of the German silver wire, and the strength of the current in the bath is thereby rendered greater or less. Accordingly he effects this object by connecting each coil of the wire around the bar of non-conducting material to a point or stud placed in a convenient position for the aforesaid key or lever to be brought in contact therewith as desired. The said key or lever is so connected in the electrical circuit that the current passes through it and through that part of the coil with which it may be in connection, thus making the circuit longer or shorter. As a convenient manner of operating, he fixes the points or studs and the key or lever upon a board or plate, the whole to be placed in a convenient position upon the dynamo-electric machine, so that the workman or attendant may readily shift the key as required, according to what strength of current is wanted in the bath at any particular time. In connection with this arrangement he provides a galvanometer, which is placed in the circuit, and indicates at all times the number of revolutions the machine is making. It is desirable that the machine should be kept at the same speed, otherwise the placing of the key or lever on any one point or stud would not ensure the same strength of current in the bath. As the galvanometer indicates the speed, the attendant is able to regulate the same should it fall below or exceed that which it is desirable to maintain.

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A SYSTEM OF TRANSMITTING TELEGRAPHIC MESSAGES FOR THE USE OF NON-EXPERTS.

I have lately constructed an apparatus by means of which anyone can transmit or decipher telegrams, using the Morse system, without previous study. I must premise, however, that my plan is designed only for use in exceptional cases, and not in ordinary telegraphy, where the skill of a professional operator is indispensable. The illustrious Morse himself invented, if I mistake not, an apparatus to enable non-experts to send messages, but it was too complicated and difficult of transport to be of much practical value.

My apparatus consists of a square piece of cardboard that can be folded into four for convenience of carriage. In this are made a number of openings parallel to each other and to the sides of the cardboard, so that, passing underneath a thin sheet of metal, the surface shows so many metallic rectangles separated from each other by equal intervals, one for every sign required in telegraphy. Thus the letter A would be represented by a short metallic rectangle followed by a longer one, the letter itself being clearly written to the left of the signs. Of the four compartments of the board, two are occupied by the alphabet, one by the stops, and one by the ciphers.

In order to send messages by means of this board a little fork must be used composed of two conducting wires, insulated from each other, enclosed in a glass tube to the ends of which they are fastened.

At one end the tube terminates in two tongues of metal elastic, and parallel to each other at a distance of about two millimetres, and communicating respectively with the two wires within the tube. These latter are also attached to two other wires, flexible in the highest degree, and insulated from each other, which communicate with Nos. 1 and 3 of the key board, so that the two tongues form the ends of an open circuit which will be closed every time that an arc of conductivity is formed from the one to the other.

It is easy to see, then, that drawing the fork with a certain degree of uniformity over the various series of metallic plates there will result such and so many completions and interruptions of the circuit as to form the dots and dashes of the Morse alphabet. In practice I have found the system answer admirably, giving the signs with the utmost regularity and clearness.

I may observe that the metal fork should not be too stiff, in order that it may press lightly on the plates, and further, that these latter should be prepared so as to resist the ordinary influence of the air.

I need scarcely point out how useful this apparatus would prove in various cases, such, for instance, as summoning the fire brigade from distant stations. It is also admirably adapted for field telegraphy.

I have only to add that, to enable non-experts to read messages received, I have devised a card, having the letters of the Morse alphabet disposed in groups according to the number of signs in their composition. In this way the receiver, having counted the number of dots and dashes in the letter, has to search only in a limited group, instead of looking through the whole alphabet.

GIUSEPPE SERRA CARPI, in *la Natura.*

THE BRUSH ELECTRIC LIGHT SYSTEM.

BY PAGET HIGGS, C.E., LL.D.

One of the most successful and practical of electric-light machines in comparison with the earlier forms, proves more easily the immense powers derived from the application of the principle known as that of *mutual accumulation.* This principle, first patented by Mr. C. F. Varley, and subsequently discovered, it is said, simultaneously by Sir Charles Wheatstone and by Dr. Werner Siemens, consists in passing through the coils of the electro-magnet (substituted for the permanent magnets) the current generated by the revolving coils, this current being developed *ab initio* by the magnetism never completely absent from the iron core of an electro-magnet. The increase of magnetism caused by the increase of current in the coils of the electro-magnet increases the current induced in the revolving coils, and there thus occurs a development of current at compound interest, and this means of development is an application of the principle of mutual accumulation. Mr. Brush, the inventor of the machine bearing his name, considers that even the best forms of magneto-electric apparatus are unnecessarily heavy, bulky, and expensive, and are more or less wasteful of mechanical power.

The armature of the brush machine is of iron, in the form of a ring, and is attached to a hub (Fig. A). This hub is rigidly attached to a shaft, which, when driven by the pulley, causes the armature to revolve in its own plane. The armature, instead of having a uniform cross section throughout its circumferential length, as is customary with annular armatures, is provided with grooves or depressions in a direction at right angles with its magnetic axis or length. The grooves are wound full of insulated copper wire. The sections of wire thus formed are of any suitable number. The advantage of winding the wire on the armature depressions is twofold: (1). The projecting portion of the armature between the sections of wire may be made to revolve very close to the poles N N and S S of the magnets, from which the magnetic force is derived, thus utilising the inductive force of the latter to a much greater extent than is possible in the case of annular armatures entirely covered with wire, which therefore cannot be brought very near the magnets. (2). Owing to the exposure of a very considerable portion of the armature to the atmosphere, the heat, which is always developed by the rapidly succeeding magnetisations and demagnetisations of armatures in motion, is rapidly dissipated by radiation and convection.

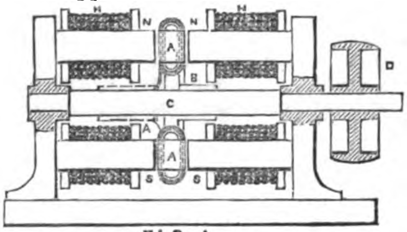

FIG. A

In the case of armatures entirely covered with wire, the escape of heat is very slow, so that they must be run at a comparatively low rate of speed, with corresponding effect, in order to prevent injurious heating.

Diametrically opposite sections on the armature may have their first or their last ends joined together, and their remaining ends connected with two segments of metal of the commutator cylinder, which is carried by the shaft, and is of insulating material. The two metal segments are placed diametrically opposite each other on the cylinder, and are each of a length less than half the circumference of the latter, thus exposing the insulating cylinder in two places diametrically opposite each other and alternating with the metal segments. In this arrangement the number of segments is equal to the number of sections, each segment being connected with but one section. The first and last ends of each section can, however, be attached to two diametrically opposite segments, the commutator cylinder in that case being constructed with double the number of segments, as in the former case, thus making the number of segments double the number of sections. Two metallic plates, or brushes, insulated from each other, press lightly upon the cylinder, at opposite points, so selected that while each section of wire on the armature is passing from one neutral point to the other, the corresponding segments on the cylinder will be in contact with them.

These plates or brushes collect the currents of electricity generated by the revolution of the armature, one being positive and the other negative. When the section of wire is passing the neutral points on the armature, the plates are in contact with the insulating material of the cylinder between the corresponding segments, thus cutting the section, which is at the time useless, out of the circuit altogether. The necessity of thus insulating each section from the plates during the time it is inactive becomes obvious, when it is considered that, if this were not done, the idle section would afford a passage for the current generated in the active sections. During the time a section or bobbin is passing from one neutral point of the armature to the next one, an electric impulse, constant in direction, but varying in electromotive force, is induced in it. This electromotive force, starting from nothing at the neutral point, quickly increases to nearly its maximum, and remains almost constant until the section is near the next neutral point, when it rapidly falls to zero as the neutral point is reached. The insulating spaces are made of such a length that a section or bobbin is cut out of the circuit, not only when it is at the neutral points, but also during the time when its electromotive force is rising and falling at the beginning and end of an impulse.

If the insulating space is too short, so as to keep or bring a section in the circuit while its electromotive force is low, then the current from the other sections, being of superior electromotive force, will overcome this weak current, and discharge through this section.

If the insulating spaces are a little longer than necessary, no material inconvenience results. A suitable length for practical purposes is easily determined experimentally. It is found in practice that the neutral points of the armature in motion are considerably in advance of their theoretical position, this circumstance being attributed to time required to saturate any point of the armature with magnetism, so that the given point is carried

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beyond the point of greatest magnetic intensity of the field before receiving its maximum charge.

It is necessary to adjust the commutator cylinder on the revolving shaft of the machine with special reference to the neutral points of the armature when in motion, in order that its insulating space may correspond with the neutral points. This adjustment is made experimentally as follows :—The commutator cylinder having been placed approximately in its proper position, the machine is started, and the presence or absence of sparks at the points of contact between the plates and commutator cylinder is noted. If sparks occur, the commutator cylinder is turned slightly forward or backward on its axis until the sparks disappear.

The presence of sparks when the commutator is even slightly out of its proper position is easily explained. If a break between a pair of segments and the plates occurs while the corresponding action of wire on the armature is still active, a spark is produced by the interruption of the current, while, if the break occurs too late, the section in question will have become neutral, and then commenced to conduct the current from the active sections, and the interruption of this passage causes a spark in this instance. If the commutator is much removed from its proper position in either direction, the sparks are so great as to very rapidly destroy both the commutator and the brushes, while the current from the machine is correspondingly diminished.

With the arrangement, where the first and last ends of each of two diametrically opposite sections are attached to two opposite segments, the intensity of the induced electric current will be that due to the length of wire in a single section only, while the quantity will be directly as the number of sections. By doubling the size of each bobbin, and diminishing their number one-half, a current of double the intensity and one-half the quantity of the former will be obtained. This effect, however, can be secured in another manner, by connecting the first and last ends of the two opposite sections together, and joining the remaining ends only to two opposite segments. This arrangement is found most convenient in practice.

The arrangement of the cylinder with segments is usually replaced by another, in which the last end of one section and the first end of the succeeding one may be connected with a strip of metal attached to the cylinder, parallel with its axis, as in the Siemens and Gramme machines.

These metallic strips or conductors are equal in number to the sections of wire on the armature, and are insulated from each other. The plates press upon the cylinder in this case at points corresponding to the neutral points of the armature, thus being at right angles with their position in the first arrangement. This plan, which is the one commonly used with annular armatures, gives fair results, but is subject to a serious disadvantage from which the first is free.

The difficulty is that the sections of wire when at or near the neutral points of the armature, contribute little or no useful effect, but the current from the other sections must pass through these in order to reach the plates, thus experiencing a considerable and entirely useless resistance; and owing to the opposite directions of the currents through the active sections on opposite sides of the neutral points, these currents, by passing through the idle sections, tend strongly to produce "consequent" points in the armature where the neutral points should be, thus interfering seriously with the theoretical distribution of the magnetism of the armature.

The electro-magnets are excited by the whole or a portion of the electric current derived from the revolving armature, as is usual in apparatus of this kind, the novel feature of this part of the machine consisting of the manner in which the magnetic poles are presented to the armature. This arrangement is such that a very large proportion of the entire surface of the armature is constantly presented to the poles of the magnets, thus securing uniformity of magnetisation as well as maximum amount. The iron segments constituting the poles of the magnets are arranged on both sides of the armature. The pieces N N, or S S, may be connected at their outer edges, thus forming one piece, and enclosing the armature still more. This arrangement is, in fact, adopted by the inventor for small machines, inasmuch as one electro-magnet may thus be used instead of two, the effect being the same, only less in degree, while the construction of the machine is simplified.

Of course, permanent steel magnets may be employed in these machines instead of electro-magnets, and this substitution is advisable in small hand machines.

In other dynamo-electric machines no magnetic field is maintained when the external circuit is opened except that due to residual magnetism; hence the electromotive force developed by the machine in this condition is very feeble. It is only when the external circuit is closed through a resistance not too large tha powerful currents are developed, owing to the strong magnetic field produced by the circulation of the currents themselves around the field magnets. Such machines are not well adapted to certain kinds of work, notably that of electro-plating. For this purpose a machine arranged to do a large quantity of work at one operation may fail entirely to do a small quantity, because of the comparatively high external resistance involved in the latter case, at the low electromotive force of the machine at the start. Again, during the process of electro-plating a very considerable electromotive force is developed in the plating bath, in a direction opposed to the current from the dynamo-electric machine. If now the current is momentarily weakened, by accident or otherwise, its magnetic field, and consequently its electromotive force, are correspondingly reduced. If the latter falls below the electromotive force of the bath, it will be overcome by it, and the machine will have the direction of its current reversed. This accident often happens with plating machines, and is a source of much annoyance. It will now be obvious that, if even a moderately strong magnetic field be constantly maintained within the machine, both of the above-described difficulties will be eliminated. Other useful applications of a "permanent field" machine will readily suggest themselves.

By diverting from external work a portion of the current of the machine, and using it either alone or in connection with the rest of the current for working the field magnets, the permanent field may be obtained.

The latter plan is especially useful for electro-plating machines. If the external circuit be broken entirely, the magnetic field will, in the former plan, remain unimpaired; and, in the latter plan, will remain sufficiently strong to effect the desired end.

Mr. Brush winds the cores of the field magnets with a quantity of a comparatively fine wire, having a high resistance in comparison with that of the external circuit and the rest of the wire in the machine. The ends of this wire are so connected with other parts of the machine that, when the latter is running, a current of electricity constantly circulates in the wire, whether the external circuit be closed or not. The high resistance of this wire prevents the passage through it of more than a small proportion of the whole current, capable of being evolved by the machine, therefore the available external current is not materially lessened. When this device, called a "teaser," is used in connection with field magnets, also wound with coarse wire, for the purpose of still further increasing the magnetic field by employing the main current for this purpose, then the "teaser" may be so arranged that the current which passes through it will also circulate in the coarse wire, thus increasing efficiency. By this device also, in electric lighting, the total cessation of the current is prevented. In the abstract of the report of the Franklin Institute will be found the results of working this machine.

Brush's lamp is illustrated in Fig. B, a helix of insulated wire, in the form of a tube or hollow cylinder resting upon an insulated plate, upheld by a metallic post or standard. With the cavity of the helix is contained the iron core and the rod which passes loosely through the core. The core is also made to move very freely within the cavity of the helix, and it is partially supported within the cavity by the springs, whose tension is regulated by the set screw. These springs push upward against ears attached to the core. A brass ring, one edge of which is over a lifting tongue which is attached to the core, while the opposite edge of the ring is a short distance below the crown of an adjustable set screw. The upper standard is fastened to a suitable base, to which is also attached the mechanism for holding the lower carbon. This mechanism consists of a support, terminating in a part similar in construction to the upper holder. The lower part of this support is bent at a right angle and rests upon the base, and is fastened by a thumb-screw. It is necessary that the carbons should present in accurate opposition to each other, and to accomplish this the set screw is made to pass through a hole in the support considerably larger than the shaft of the set screw.

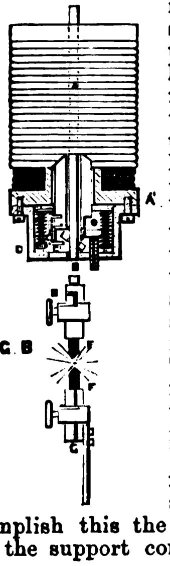

FIG. B

If one pole of a battery or other source of electricity be attached to the support while the upper pole is connected to the upper support, the electric current passes from the latter through the helix, the rod and carbons, down to the support, thus completing the circuit. The core, by force of the axial magnetism thus created, is drawn up within the cavity of the helix, and, by means of the finger, lifts one edge of the ring, until, by its angular infringement against the rod, it clamps this rod, and also lifts it up to a distance limited by the adjustable stop. While the ring

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retains this angular relation the rod will be prevented from moving.

While the electric current is not passing, the rod can slide readily through the loose ring and the core, and in this condition the force of gravity will cause the upper carbon to rest upon the lower carbon.

If a current of electricity is passed through the apparatus it will effect the lifting of the rod and separate the carbons, thus producing the electric arc.

The tension of the springs is so adjusted that they, together with magnetic attraction of the helix, shall be just sufficient to support the core, rod, and carbon, in the position for producing the arc. As the carbons burn away, increasing the length of the arc, the electric current diminishes in strength, owing to the increased resistance. This weakens the magnetism of the helix, and the core, rod, and carbon are moved downward by the force of gravity until the consequent shortening of the voltaic arc increases the strength of the current and stops this downward movement. After a time, however, the clutch-ring will reach its floor or support, and its downward movement will be arrested. Then any downward movement of the core, however slight, will at once affect the rod, allowing it to slide through the ring until it is arrested by the upward movement of the core, due to the increased magnetism.

In continued operation, the normal position of the ring is in contact with its lower support, the office of the core being to regulate the sliding of the rod through it.

If, however, the rod accidentally slides too far, it will be instantly and automatically raised as at first, and the carbon points thus continued in proper relation to each other. The success of the system in America is well instanced in the following cases:—In the City Park, Cleveland, Ohio, the park is lit by twelve Brush lights, of 2,000 candle-power each; the machine absorbs eleven indicated horse-power, it yields eighteen lights in one circuit with thirteen and three-fourths horse-power; the lamps burn without the slightest attention fourteen hours continuously; the cost to the city, as per contract with the Telegraph Supply Company, is 4½d. per hour for each light, and the twelve lights give at least three times as much effective light as was formerly yielded by over 100 scattered gas burners. It will be seen that the Brush light is at least six times as effective as the Jablochkoff system. Each lamp consumes about two inches of carbon per hour, costing one halfpenny. The light burns from eight in the evening until four o'clock in the morning (the time specified in the Council's schedule) without alteration. The photometric power of the light is equal to 2,000 candles. The opal globes cut off at least one-half of this light, leaving its power equal to about 60 five-feet gas burners. This amount of light is as effective as twenty-five to thirty gas burners scattered over the space lighted by each electric light, making the twelve lights used in illuminating one of the squares as effective as 350 gas burners.

Prominent among the users of the light are the following:—John Wanamaker, of Philadelphia, fifty-six lights for his grand depot, the largest retail store for that country. The Riverside Mill, manufacturing woollen goods and running all night, are using in place of gas forty-eight Brush lights, obtaining a far better light at less than one-third the amount formerly paid for gas, the cost of electric light being inclusive. The Conant Thread Company, of Pawtucket; the Williamantic Linen Company, of Williamantic, Connecticut; the Merrimack Cotton Mill, of Lowell, Mass.; Washburn and Moen Wire Mills, of Worcester, Mass.; the Phœnixville Iron Company, of Phœnixville; the Edgemoor Iron Company, of Edgemoor; the Pennsylvania Steel Company, of Baldwin Station; the Atlantic Refining Company, of Philadelphia; the Palace Hotel and the Union Iron Works, in San Francisco; the Marysville Hydraulic Mine in Marysville are other instances, though by no means all, of its successful daily use.

INTERNATIONAL TELEGRAPH CONFERENCE—VISIT TO FOOT'S CRAY.

On Saturday last the members of the Conference, together with nearly 500 ladies and gentlemen invited to do honour to the occasion, proceeded from Charing-cross Station to Sidcup, by a special train chartered by Mr. John Pender, M.P., in order to join a garden party at that gentleman's residence, an old-style Italian villa, known as Foot's Cray Place, and formerly occupied by Lord Bexley. From Sidcup station the guests were conveyed in private carriages to their destination, where they were received by Mr. and Mrs. Pender. Amongst those present were:—The Marquis of Tweeddale, Lord and Lady Alfred Churchill, Miss Churchill, General Lord Mark Kerr, General and Lady Jane Taylor, Comte and Comtesse Batthyany, Mademoiselle Bourneman, Earl of Galloway, Earl and Countess of Lindsay and Miss Dallas, Viscountess Gort and Hon. Miss Vereker, Viscountess Strangford, Lady Jane Dundas, Mr. and Lady Frances Trevanion, Lord Houghton, Lord and Lady Camoys, Lord Hammond, Lady Marjoribanks, Hon. Mrs. Tomline, Hon. Mrs. Skeffington Smyth, Hon. Ashley and Mrs. Ponsonby and Mr. Claud and Mr. Eustace Ponsonby, Hon. Mrs. St. Clair, Hon. Robert Neville and Mrs. Lawley, Hon. Slingsby and Mrs. Bethell and Miss Bethell, Hon. C. S. and Mrs. Hanbury Lennox, Hon. Albany and Mrs. Erskine, Hon. Frank Stonor and Miss and Mr. Henry Stonor, Hon. Ralph and Mrs. Dutton, Sir Walter and Lady Caroline Sterling, Sir Frances and Lady Seymour and the Misses Wickham, Lady Tierney, Sir Victor and Lady Houlton, Sir Julius and Lady Vogel, Lady James and Hon. Miss Strutt, Sir Henry and Lady Lefroy, Sir Henry and Lady Ingelby, Sir Daniel and Lady Lysons, Sir Henry and Lady Selwyn Ibbetson, Sir Frederick and Lady Hamilton, Sir George and Lady Waldie Griffith and the Misses Griffith, Sir John and Lady Heron Maxwell and the Misses Maxwell, Sir Graham and Lady Graham Montgomery and the Misses Graham Montgomery, Sir Sir Philip and Lady Rose and Miss Rose, Sir William and Lady Miller and the Misses Miller, Sir Edward and Lady Watkin, Sir James and Lady Anderson, Sir John and Lady Heathcote Amory, Major-General Tremenheere and Miss Tremenheere, Admiral Sir Rodney Mundy, Admiral Hillyar, Mrs. Washington Hibbert, Mr. Underdown, Mr. Edwards, M.P., Mr. Cartwright, M.P., Mr. and Mrs. Julius Beer, Dr. Priestley, and Major Ludlow.

A more delightful locality than this residence, situated amid the hop gardens of Kent, and close to Chislehurst, could scarcely have been selected for a *fête champêtre*; and although the weather in the morning had been of the character which for a long time past has been but too familiar to us, in the afternoon it was exceptionally fine, allowing the party to become distributed over the grounds. The latter, well-timbered and undulating, with beautiful avenues, parterres, and magnificent beeches, afforded ample room as well as opportunity for a *promenade*, extending as they do over some two hundred acres. The house itself is extensive and picturesque; and a fine view of the surrounding country could be obtained from the balustraded terrace. This garden party, which appeared to be enjoyed by all present, was one of the largest as well as one of the most successful of the present season.

Electric Lighting.—An invention (says the *Engineering and Mining Journal*) for saving the large percentage of power wasted by generators is announced by Mr. N. S. Keith, electrician of the Fuller Electric Company. By this, a secondary circuit is supplied to the local currents, which are utilised without any increase of horse-power. A somewhat startling estimate, based on Breguet's formula, has been brought forward to show that to light New York with 30,000,000 candle-power, using for the purpose 1,000 generators, run by engines aggregating 13,000 horse-power, the copper wire alone would cost $75,000,000. As to the divisibility of light, the difficulty does not lie in any inability to control by induction, for this may be met by the multiplication of circuits, but to furnish economically a number of lights of moderate power, capable of easy management, and steady and uniform. Just as with a generator, the expense of a current increases with the square of the distance, so, in subdividing the current for the supply of a number of lamps, the cost increases in geometrical ratio to the subdivision. As to the reduction of single lights, Werdermann has run ten lamps of forty candle-power each, using four Daniell cells; and a prominent New York electrician announces that there is no difficulty in operating on the same principle 500 lamps in a circuit. Edison has constructed one of sixteen standard candles per hour, by the only successful one not based on the voltaic arc, and can reduce the light still farther; then Mr. Holcombe claims to have minimised the light by his needle-like lamp-black candle, which does not appear to go beyond what is effected by the Brush or Maxim pattern. A patent has been taken out at Washington for dividing by optical means, instead of division of current or by induction; and this by establishing one light in a house and distributing it by means of refractors and reflectors. The patentees are Messrs. Molera and Celerien, of San Francisco. Mr. Keith has applied for a patent for a new regulator, dispensing with clock-work, but retaining electro-magnets, by which the armature lifts or deflects a rolling lever, this similarly operating on the carbon-holder. The practicability and advantage of the electric light, in the character of the illumination and reduction of cost for large spaces, has been conceded by the English Parliamentary Commission, and has been abundantly illustrated in this country in the lighting of public squares, docks, and the floors of large manufactories, &c. Estimates of relative cost vary, but all are said to show a reduction on gas.

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ELECTRICAL TERMINOLOGY AND ELECTRICAL SCIENCE.

Shall we ever have—is it practicable, and would it be expedient to have—an electrical Conference that might settle, at least provisionally, disputed questions of terminology and definition, in the same way that the International Telegraph Conference is settling questions of tariff and organisation? And, if not, what representative body or what authority will decide, for instance, whether it is permissible to use such terms as "positive current," twenty "elements" of Daniell, electromotive "force," currents of high "tension," or "potential of a battery?" In regard, moreover, to terms which are in themselves unobjectionable, whither are we to look for definitions which shall be so widely accepted as to obviate the confusion which arises from the use of a term in more than one sense. Who, for instance, will decide whether *electrostatic tension* is "the *force* with which electricity tends to repel itself from a conductor," or whether, according to an older definition, it is measured by the quantity accumulated under unit conditions, and varies therefore as the *square root* of the repulsive force?

Perhaps some of our more practical and less theoretical readers might be inclined to say:—"What matters it whether such questions are settled or not? We all of us know that 'sending a positive current to line' means connecting the latter to the positive pole of the battery; that twenty 'elements' means the same thing as twenty cells; that electromotive 'force' is measured in *volts;* and that the 'potential' of a battery means its electromotive force. And whether tension is a force or the square root of a force, is a matter of little consequence, so long as we understand practically what the term implies."

To this it may be answered that, even taking the point of view from which electricity is regarded as a handicraft rather than as an exact science, the inexpediency of using equivocal and undefined terms is frequently made manifest. Thus, in one instance within our own experience, a young electrician, told to prepare "ten elements of Daniell," selected five zincs, as the positive "elements," and five coppers as the negative "elements;" and, with these ten elements, mounted a battery of five cells. The joke of the thing was that his principal had to admit that he meant, and should have said, ten "couples," or ten "cells." In another case a pupil, having had explained to him that the tension sign of the positive pole is *minus* when an insulated couple is circuited through a resistance less than its own, very thoughtfully observed:—"Then if we wish to send a *positive* current, we must be careful that the resistance of the battery is not greater than that of its external circuit?" And an intelligent learner might very naturally suppose that the "potential" of a battery cannot be the same thing as its "potential difference" or "electromotive force."

But the great majority of those who are engaged in electrical applications will agree with us that electricity must at the present day be regarded as one of the exact sciences, and that, consequently, its terminology is a matter of serious and practical moment. And all who are interested in electrical theory will agree with the observation of Prof. J. Clerk Maxwell, at page 271 of our last volume, that "there is no more satisfactory evidence of the progress of a science than when its cultivators, having settled all their differences about the connection of the phenomena, proceed to reconstruct the definitions," and, in the words of Mr. L. Cumming, "will hail with satisfaction any attempt to clear from ambiguity the language of physical science."

The general opinion will probably be that the questions we have referred to should be settled by open discussion in scientific journals, and by means of that intercourse between electricians of various grades and diverse attainments which should be fostered by our scientific authorities, rather than by any duly considered decisions of a representative body of electricians belonging to various nationalities. The immediate import of the settlement of questions which are mainly theoretical, and which only indirectly involve the progress of electrical applications, is not, it may be considered, sufficiently striking and obvious to bring about any associated action analogous to that which has been found so effective, and which has so speedily led to an agreement, in directions where pecuniary and public interests are at stake. If this unfortunately be the case, the importance of discussions such

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as that on "Potential" which was recently carried on in these pages can scarcely be overrated, provided they are found to lead virtually at least to a provisional agreement. It is of considerable interest, therefore, that these discussions should in some measure be reviewed, that their results should as far as possible be summed up, and their general effect noted.

The discussion in question brought into prominence the fact that there are at least two well-defined schools, or modes of study and observation, in electrical science, viz.: the Scholastic or Mathematical school, and the Physical or Engineering school; to which may perhaps be added the Empirical or quasi-scientific school, which, until comparatively recently, nearly monopolised the medical and also some minor departments of electricity. To the first of these schools belong such men as Professors Clerk Maxwell, Sir W. Thomson, and F. Jenkin, Mr. L. Cumming, Mr. R. E. Baynes, Professor Ayrton, and Dr. Lodge. To the second belonged at one time such men as Sturgeon and Faraday, who seldom, if ever, employed the higher mathematics as a means of investigation, and amongst its present representatives may be classed Mr. Latimer Clark, Mr. C. F. Varley, Mr. Desmond FitzGerald, Mr. J. T. Sprague, and probably—though he has not yet given expression to any theoretical views—Mr. Thomas Alva Edison. As to the third "school," its present representatives mostly keep in the background, excepting when they bring themselves into prominence in the advertising columns of papers having a large circulation. Confining our observations to the two first-mentioned schools, we observe that neither of them can be said to over-estimate the other. But we have also observed with pleasure that an encounter *à outrance*, in a fair field of discussion, between representatives of the two opposite schools of thought has generally had the effect of considerably raising each in the estimation of the other. This fact alone shows the need for extended means for intercourse and intercommunication, such as an electrical society should afford. It must, we think, be a mistake, on the part even of the most accomplished mathematician, to underrate the value of theoretical views obtained by continuous and patient examination of experimental results from a physical or engineering stand point; and assuredly it would be no less a mistake on the part of those whose investigations are grounded mainly on chemical physics to ignore the great importance of the higher mathematics in arriving at an extended and accurate appreciation of physical phenomena. The prevalence of such mistakes would be of considerable detriment to the progress, or perhaps we should say to the lateral extension, of science; whilst the discussion that tends to obviate them is one of the most powerful agents for such extension.

In considering the results which may be due to the expression by our scientific contributors and correspondents of their views on the use and meaning of the term "potential," we think we may in the first place assume that the expression "tension of a current," which Dr. Lodge has very justifiably termed a "meaningless abomination," will not in future be considered permissible either in this country or on the continent. Next, as to the use of the term "tension" in the same sense as that in which the term "potential" is now generally employed, we have to observe that Mr. FitzGerald has omitted to sum up his argument, doubtless because he saw that its drift was perfectly apprehended by Dr. Lodge and the majority who were against him in this matter. We may be permitted therefore to summarise this argument in the briefest possible form. If the symbol W be taken to express electrical work, or, rather, potential energy, Q electrical quantity, V electrostatic potential, and R inductive resistance, or the reciprocal of inductive capacity, the argument may be expresssed as follows:—

$$\text{If} \quad W = \frac{QV}{2},$$

$$\text{then} \quad V = \frac{2W}{Q}.$$

$$\text{But} \quad W = \frac{Q^2 R}{2}.$$

$$\text{Therefore} \quad V = QR.$$

This last product, according to Mr. FitzGerald, being the recognised expression for "tension."

Now, without venturing to decide upon the question at issue, we may observe that although Mr. Latimer Clark, Mr. Mr. F. C. Webb, Mr. FitzGerald, and some others may consistently have used the term "tension" strictly in the sense indicated by the above equation, that is to say, in the sense of "potential," the former term has undoubtedly been frequently employed in a different sense, and has in consequence obtained the bad repute which follows upon equivocation. The argument is in fact answered by Dr. Lodge in the following words:—"As to recognising his old friend *Tension* in this definition, it depends entirely on what he has meant by 'tension.' The great objection to this word is that it has been used in such a vague way, to mean anything and almost everything; but it is possible that a man of Mr. FitzGerald's experience has, like Mr. Latimer Clark in his useful little book, used the word with a fixed meaning, viz: the meaning which other people (in a rather better defined manner) attach to the word *potential*." But, in our opinion, the term "potential" has a more extended meaning than was ever attached to the term "tension." The former term has become so well established that it is not at all likely that it will ever be relinquished; and the probability is that the latter term will gradually, even amongst our continental neighbours, become limited to the signification of "strain in the dielectric per unit of area."

In the course of the discussion, a most important theoretical point, which has frequently been insisted upon but has never, we think, received the consideration it deserves, was brought into prominence by Mr. Robert E. Baynes. This gentleman pointed out that the mathematical dimensions of electrostatic potential are not those of *force;* (taking this term in its accurate dynamical meaning) but are those of the *square root of force.* Mr. L. Cumming, however, observes that this is the case only when electrostatic measure is taken, and that the dimensions of potential are different in electromagnetic measure. In any case, it appears tolerably evident, from Coulomb's law of electrical attraction and repulsion, as well as from other considerations, that difference of potential, or what is ordinarily symbolised by E in the equation expressing Ohm's law, cannot with any scientific accuracy be termed a "force," and that therefore the term "electromotive force" is a misnomer. We should ourselves have no hesitation in substituting for it the term "potential difference," suggested by Mr. Baynes, were it not for some observations relative to this question, by so high an authority as Professor Clerk Maxwell, which will be found at page 271 of our last volume. It is there stated that, outside of electrostatics, "we have to deal with electromotive force in cases where potential, and, therefore, potential-difference are words without meaning." If this objection cannot be overcome, if we cannot in all cases of electrical action realise electromotive "force" as being in all cases due to a difference of potential, albeit this may be sudden in its effect and of temporary duration, then we would seem to be in presence of a very

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awkward trilemma. If we speak of electromotive "force" we perpetuate a general inacuracy, if we use the expression "potential-difference" we are inaccurate in particular cases, and any other term, supposing it to be invented, would, even if accurate, be objectionable until its meaning became recognised by common consent. We earnestly invite our theoretical readers, and all those who are able to render aid in the improvement of electrical terminology, to rescue us from this difficulty, or, better still, to point out, if possible, that those who assume its existence are under a misapprehension. And, in conclusion, we commend to the attentive perusal of electrical students the valuable communications on the subject of "potential" with which we have been already favoured.

SIR WILLIAM FOTHERGILL COOKE.

The death of Sir William Fothergill Cooke, better known as plain Fothergill Cooke, is an event which, at his advanced age, excites no surprise; but occurring at this present time it has a significance, and if we may be permitted to say so, an appropriateness which is almost unique. Sir William lived to see his ideas worked out to their utmost conclusions, and his labours rewarded far beyond all expectation. The harvest, indeed, has been so busy and so bountiful that the sower would seem to have been almost forgotten. At a moment when the newspapers are devoting columns to the doings of the representatives of the world's telegraph systems, an obscure paragraph briefly announces the decease of him to whom, more than to any one man, the telegraph world owes its existence. He was literally the father of English electric telegraphy; and in a not very remote sense the father also of electrical signalling throughout the world.

An authentic memoir of Cooke, and especially of his achievements in telegraphy, would be of considerable interest just now. The materials are not yet forthcoming, and are nowhere at present free from elements of dispute as to priority of claims and pretensions about this and that discovery. They are for the most part trivial questions, and sink into insignificance beside the great and undisputed facts of his career.

Overshadowed by the later inventions of the eminent man whose name was usually associated with his own, Cooke's original contrivances have in these times had scant justice done to them, some people supposing that he "found the money," or "hit upon the idea;" while in any case Wheatstone found all the brains. This is by no means the fact. Cooke was a man of considerable scientific attainments, and of keenest insight, which, coupled with his indomitable perseverance, would probably have carried him through single-handed. But he found it to his advantage at a critical moment to accept the assistance of a professional expert, and nominally the patents were the joint products of Cooke *and* Wheatstone. How far they were really so it is not our aim to question. All that we desire to recall attention to is the fact that the introduction of a practical system of electric telegraph into this country was Cooke's own property; and its final adoption and success were due to his energy, skill, and good management.

The last paragraph of the award in the arbitration between the claims of Cooke and Wheatstone by Sir M. Isambard Brunel and Professor J. F. Daniell, fairly closes discussion as to the relative work of the colleagues. The arbitrators say, "Whilst Mr. Cooke is entitled to stand alone as the gentleman to whom this country is indebted for having practically introduced and carried out the electric telegraph as a useful undertaking, promising to be a work of national importance, and Professor Wheatstone is acknowledged as the scientific man, whose profound and successful researches have already prepared the public to receive it as a project capable of practical application, it is to the united labours of two gentlemen so well qualified for mutual assistance that we must attribute the rapid progress which this important invention has made during the five years since they have been associated."

Both Cooke and Wheatstone "cordially acknowledge the correctness of the facts" in this award.

Cooke was born at Ealing in 1806; and his father, Dr. Cooke, gave him a liberal education—begun at Durham, and completed at Edinburgh. At the age of twenty he entered the East India Company's army; but retired after a few years service. He then appears to have contemplated following his father's profession, for in 1833, or thereabouts, we find him studying anatomy and physiology in Paris and Heidelberg. It was at this latter place that Cooke got his first conception of the electric telegraph. He says, "I happened to witness one of those well-known experiments on electricity considered as a possible means of communicating intelligence, which had been tried and exhibited from time to time during many years by various philosophers. . . . Within three weeks I constructed a practical electric telegraph of the magnetic needle form."

About the 6th March, 1836, Professor Möncke, of Heidelberg, showed by experiment that electric currents conveyed by wires to a distance could be then caused to deflect magnetic needles, and thereby to give signals. His apparatus consisted of two instruments for giving signals by a single needle, placed in different rooms, with a battery belonging to each, copper wires being extended between the two termini. The signals given were a cross and a straight line, marked on the opposite sides of a disc of card, fixed on a straw, at the end of which a magnetic needle was suspended horizontally in galvanometer coils by a silk thread. This was in March, 1836; and within a year from that date Cooke had converted that crude device into a practically serviceable needle instrument. Besides this, he had constructed an alarum, using an electro-magnet to release the indent—a principle which has been the parent of many telegraphic appliances since then. The principle of removing a detent by magnetic attraction, and replacing it by mechanical reaction was not, however, confined to the alarum, "but was the basis of the mechanical telegraph." The first application of the principle was to a musical snuff box, "being almost the only piece of mechanism I was then acquainted with." The first patent was taken out in May 1837; and upon the experimental line between Euston-square and Camden Town, and the short working line from Paddington to West Drayton, was built the gigantic superstructure of English telegraphy which we see at the present day. In 1867 the Society of Arts awarded him the Albert Gold Medal, and on the 11th November, 1869, he received the honour of knighthood.

There was much uphill work to be accomplished, prejudices to be overcome, capital to be raised, and faint hearts to be encouraged, before the formation of the great Electric Telegraph Company in 1846 placed the future of telegraphy out of all danger. But Cooke was possessed of natural advantages which eminently fitted him to succeed. Of commanding presence, even temper, and genial manners, he inspired confidence wherever he went. In the language of those who knew him best, he was a "splendid fellow;" and to anybody with eyes to see, he was, indeed, a notable personage—one of those stout Britons whom we are proud to call the pioneers of English enterprise. The Delegates from Telegraph Administrations of almost every civilised country in the world are now sitting in conference on English soil. The patriarch of telegraphy might fittingly sing his *Nunc Dimittis* at such an epoch—let us hope it may have been in peace.

TRANSFORMATION OF ENERGY.*

The subject I propose to bring before your notice this evening is one, to the development of which we owe the great strides which science has taken during the last half century. Though peculiarly physical, the modern doctrine of energy has an important bearing upon all branches of science; and it is well that those whose professional duties touch in any way upon any of these many branches of science should have clear notions of what is really meant by energy. Philosophers are wont to speak of matter and mind as if they were the only things which could be reasonably assumed to exist in the universe. We believe in the existence of matter because it affects our senses; but the great argument in favour of the objective existence of matter is its indestructibility—that is, the impossibility as far as our experience goes, of destroying matter or of creating matter. We can only shape matter, transfer or transform matter, but never has matter by pure physical means been called into existence. Now in nature there is another something, far subtler than matter, but possessing this same property of indestructibility—a something, too, which can be traced in its actions in the material universe; and this something, which we call energy, has as real and objective an existence as matter itself. The energy of a material system is usually defined as the capacity the system possesses for doing work. For example, in lifting a stone I do work against its weight, and the energy required to do that work was originally stored up in my muscle. The work I do is measured by the product of the force overcome into the distance through which it is overcome—*i.e.*, by the product of the weight

* A lecture by Mr. Cargill G. Knott, B.Sc.

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of the stone into the height through which it is raised. Say I raise a pound weight twenty feet, then I perform twenty foot pounds of work. In raising the stone I have suffered a certain fatigue, I have lost energy, but this energy, though lost to me, is not lost to the world, it is stored up in the raised weight, which has now, because of its position above the earth's surface, a certain capacity for doing work. This energy of position in the mass is measured by the amount of work which I originally performed on it—namely, 20 foot pounds; but if the mass be permitted to descend, it, in its turn, will lose this stored up energy which will become transformed more and more into energy of motion as the mass, descending, gains in velocity. At the instant the mass touches the earth, the stored up 20 foot pounds of energy will be wholly transformed into energy of motion, which the mass still possesses. After the impact, however, the mass is brought to rest; it has been unable to overcome the resistance offered to its motion by the earth's surface; it has lost its energy, but this energy reappears in the heat and sound which are developed at the instant of impact. I have thus traced a certain portion of my muscular energy through a variety of transformations which ultimately end in the generation of heat. Throughout it all, however, the quantity of energy has been unaltered. Illustrations might be multiplied indefinitely. To-night I shall confine myself to electrical illustrations.

Let us consider a galvanic battery as our source of energy, and let us follow the transformations of part of this energy as exemplified in well known electrical experiments. The energy of the galvanic current is derived in the first place from the combustion of the zinc in the Bunsen cells which form the battery, and this combustion depends upon chemical action, which is simply a transformation of potential energy of molecular distribution. Into this we cannot enter at present, but pass on to the consideration of the electric current and the various ways in which it may be employed to do work. A current flowing along any conductor experiences a certain resistance, to overcome which it does work, and the energy which it so loses is transformed into heat. By passing the current through a thin iron wire, the heat generated is sufficient to make the wire glow till it melts. This process is familiar as a method by which mines are frequently blasted. Electrolysis or decomposition of a liquid (such as dilute acid) by the passage of a current affords another striking example. Here the energy of the current is expended in pulling the molecules asunder so as to separate them into their constituents. The hydrogen and oxygen into which acidulated water is decomposed may be collected in a vessel and exploded, when the sudden expansion of the water vapour produced by the combustion of the hydrogen in the oxygen causes a violent disturbance in the air, which is evidenced as sound. In this form we partly recover the energy which the current originally lost in effecting the decomposition. The discovery by Oersted in 1820 of the motion of a magnet by a current flowing near and parallel to it supplied the link which was wanting between electrical and magnetic phenomena. An electric current is as much the seat of magnetic action as a magnet is, and by suitable means the energy of the current may be transformed into the energy of magnetism. Wherever a current is flowing, there, of necessity, is a magnetic field; and if any system is acted upon energetically when placed in this field, as is the case with a magnet or a piece of iron, the current loses a certain part of its energy, which is first transformed into energy of motion, ultimately, as in all transformations, taking the form of heat. Thus, by passing a current through a wire coiled round a soft iron bar, the iron acts for the time as a magnet, and, indeed, all the phenomena of magnetism can be produced by means of helices or spirals of conducting wire. But not only does a current affect a magnet in its vicinity, but a magnet moving in the vicinity of a coil generates a current in the coil. More generally, if a magnet and conductor are in relative motion, currents are induced in the conductor, which, by the attraction or repulsion upon the magnet, tend to stop the relative motion. This is the explanation of the damping effect which a conductor set below a vibrating magnet has upon the vibrations of the magnet, and of Arago's famous experiment in which a magnet placed upon a rotating horizontal copper disc is dragged round after the disc. All these are special cases of induction, the nature of which was first thoroughly studied by Faraday, and all are included under the following general proposition. When the magnetic field in which a conductor is set is in any way altered, currents are induced in the conductor, which by their magnetic action tend to resist the alteration. This alteration may be effected by moving a magnet near a conductor, or a conductor near a magnet, or by mutual motion of a current-traversed coil and a conductor, or by altering the intensity of the current flowing in the vicinity of a conductor. Upon this principle depends the action of the various forms of magneto-electric machines which are now so much used in the production of the electric light, as well as of the Ruhmkorff's coil or inductorium, whose working, as affording interesting examples of transformations, we shall consider in greater detail. The induction coil consists essentially of two coils, the thicker internal one being the primary, and the thinner, but longer external one, the secondary. Inside the interior of the inner or primary is a bundle of iron wires, terminated at its extremities by discs of soft iron. When a current is passed through the circuit, the iron core becomes an electro-magnet, attracts a small iron disc, which forms the extremity of one arm of a lever, whose other extremity is consequently displaced, and by its displacement breaks the primary circuit. The current accordingly ceases to flow, the soft iron core loses its magnetism, and the lever returns to its original position, thus completing the circuit, and permitting the current anew to flow. The same cycle of operations takes place again, and thus an automatic or self-governing arrangement is produced, by which the current is made and broken in rapid succession. But at each make and break of the primary an alteration of the magnetic field results, and alternating secondary currents, rendered the more intense by the presence of the iron core, are induced. By this means a rapid series of sparks is obtained between the terminals of the secondary coil. To overcome the great resistance which the air presents to the passage of the spark, the second current must do work, and the energy so lost reappears as light, heat, and sound, which are the invariable accompaniments of the spark. The beautiful combinations of coloured and stratified lights produced by passing the currents through Geissler vacuum tubes illustrate the same principles, and in all these varied transformations of our original source of energy the grand conservation law holds without exception. Naturally, however, energy, in whatever form it may exist, tends to the ultimate form of heat, which cannot be prevented from diffusing gradually all round. But this diffusion diminishes its power of being transformed, diminishes its availability for doing work. Hence at every transformation energy becomes degraded, or, as it is commonly expressed, dissipated; that is to say, though its total quantity remains constant, its entropy or availability for work is diminished. Ultimately, then, unless the energy of the material universe is infinite, its entropy will become zero, and the universe be reduced to a lifeless, motionless, characterless mingling of matter at a uniform temperature.

ON HIGH ELECTRICAL RESISTANCES.

BY J. HOPKINSON, F.R.S., D.SC.*

In the *Philosophical Magazine* of July, 1870, Mr. Phillips describes a method of readily constructing very high electrical resistances. A pencil line is ruled on glass, the ends of the line are provided with the means of making electrical connection, and the whole is varnished. By this means a resistance of two million ohms was obtained, and it was found to be constant under varying potential. This method of constructing resistances is alluded to in Maxwell's "Electricity" (p. 392); but I do not know that it has received the examination it deserves, or that it has come into general use. Having need of resistances of over 100 million ohms, I have made a few on Mr. Phillips's plan, ranging from 26,000 ohms to 96,000,000 ohms (which are fairly satisfactory), and one or two much greater (which do not conduct according to Ohm's law, but with a resistance diminishing as the electromotive force increases). A short description of these may perhaps save a little trouble to others who desire tolerably constant high resistances.

All my resistances are ruled on strips of patent plate glass which has been finished with fine emery, but has not been polished. The strips are 12 inches long, and, except in the cases specified below, about half an inch wide. One or more parallel lines are ruled on each strip, terminating at either end in a small area covered with graphite from the pencil. The strip of glass, first heated over a spirit lamp, is varnished with shellac varnish, excepting only these small terminal areas, which are surrounded by a small cup of paraffin wax to contain mercury to make the necessary connections. To secure better insulation, feet of paraffin or of glass covered with paraffin are attached on the underside at the ends of the strip to support it from the table. Before varnishing, each strip was marked with a distinguishing letter. The strips marked *g*, *h*, *i*, *a*, and *b* were ruled with a BB pencil, the remainder with a HHH.

These resistances appear to be not quite constant, but to vary slightly with time, the maximum variation in four months being slightly in excess of ½ per cent. In every case they were examined under varying potential to ascertain if they obeyed Ohm's law.

* From the *Philosophical Magazine* for March, 1879.

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With the exception of f, described below, all were satisfactory in this respect. The resistance appears to diminish slightly as the temperature rises; but this conclusion rests on a single rough experiment, and must be regarded as uncertain.

The values of the resistances were determined with a differential galvanometer, each coil having a resistance of 3,500 ohms, by the well-known method of dividing a battery current, passing one part through the large resistance to be measured and one coil of the galvanometer, the other through a set of coils or other known resistance, and then through the galvanometer shunted with a second set of resistance coils. g was thus compared with standard coils. g was then used to find h and i, and $h + i$ was used to find a and b. A Thomson's quadrant electrometer was used to compare in succession k, l, and m with $a + b$. c and e were similarly compared with $k + l + m$; and, lastly, c and e were used to examine f.

g is ruled on a strip one inch wide, rather more than half the surface being covered with graphite. Three experiments on the same day gave 26,477, 26,461, and 26,470 ohms; the variations are probably due to uncertainty in the temperature-correction, the galvanometer coils being of copper. After the lapse of four months 26,615 ohms was obtained.

i is ruled on a strip three-quarters of an inch wide, with nine tolerably strong lines. Its resistance was first found to be 209,907 ohms, and four months later to be 208,840.

h has four strong lines on a strip half an inch wide; resistance 207,954 on a first occasion, and 208,750 after the lapse of four months.

a has two lines narrower than the preceding; resistance 5,240,000 at first, and 5,220,800 after four months.

b has a single line apparently similar to either of those of a, and the resistance is 9,168,000.

k, l, and m have each two lines ruled with a HHH pencil; their resistances are respectively 23,024,000, 14,400,000, and 13,218,000 ohms.

c and e also have two lines, but they are finer; the resistances are 79,407,000 and 96,270,000.

As already mentioned, all the preceding were tested with various battery power, and were found to obey Ohm's law within the limits of observation. It was not so with f, as the following observation shows very clearly. c, k, e and f were arranged as a Wheatstone bridge. Junctions (f, c) and (e, k) were connected to the poles of a Daniell's battery varying from one to eighteen elements; junctions (c, f) and (k, c) were respectively connected through the reversing key with the quadrants of the electrometer. The potential of one Daniell's element was represented by 270 divisions of the scale of the electrometer. Column I. gives the number of elements employed, II. the corresponding reading of the electrometer, III. the value of $\frac{k}{k+c} - \frac{e}{f+e}$ deduced therefrom, and IV. the values of the ratio resistance of f; resistance of e.

I.	II.	III.	IV.
1	16	0·060	5·1
2	25	0·046	4·6
3	31½	0·039	4·4
4	31	0·029	4·1
5	28	0·021	3·9
6	27½	0·017	3·8
9	10	0·0041	3·5
12	− 5	− 0·0016	3·4
15	− 25	− 0·006	3·3
18	− 47	− 0·0097	3·25

This result is by no means surprising. There is, doubtless, an exceedingly minute discontinuity in the fine line across which disruptive discharge occurs; and the moral is, that resistances of this kind should always be tested as regards their behaviour under varying electromotive force.

Several attempts to rule a line on a strip 12 inches long, with a resistance over 100,000,000 ohms, resulted in failure.

THE NEEDLE SYSTEM.*

BY C. H. HASKINS.

An old writer has said that the destiny of nations is frequently determined by some accident or incident so trifling that it entirely escapes notice at the time of its occurrence. That this is true we all know, not only in relation to nations, but much more frequently in the minor affairs of life. Many important discoveries in chemistry and the natural sciences are the result of accident, and almost every successful business man can recall some trifling circumstance that proved the turning point of his career.

These reflections were forced upon me, and very strongly, when examining the various telegraph systems in use in Europe. To an American they seemed, some of them, crude, and in every way inferior to ours; and yet to the fact that the systems *do* vary, and that, while we started with one system, the English took another, are due the wonderful results that have been obtained during the last thirty years.

I have before me, as I write, a pair of English single-needle Cooke and Wheatstone dial instruments, old ones, that were used for many years on one of the English lines. Very simple in construction—only an upright coil, enclosing a heavy needle, on the shaft of which is an ivory pointer. Below is a horizontal shaft, with a handle depending therefrom. Four binding posts complete the apparatus. To two are attached the line and ground wires, to the others the terminals of the battery. One would be willing to assert, on examination, that nothing could be more simple or more useless. And yet it works well, though slowly. But it has served a great purpose. Let us see.

In 1837 William Fothergill Cooke, having invented a five-needle (five-wire) telegraph, and having associated with himself Professor Wheatstone (to obtain his influence) succeeded in introducing it to the public and working it upon a telegraph line. At this time Morse was dimly thinking of his system, but had accomplished nothing. Steinheil in Germany was also working at a system which he afterwards introduced successfully. Now, as the Cooke and Wheatstone is a noiseless system, a bell magnet was used to call the office wanted; and this formed a portion of the Cooke system and does still, and when Morse and his friends in 1847 went to Europe to introduce his system, Cooke and Wheatstone claimed that his electro-magnet in his relay infringed upon their patents, as they also used an electro-magnet to ring a bell and call the desired office. This claim prevented the introduction of the Morse instruments into the British Islands. The Continental nations, however, adopted it, Steinheil among others, pronouncing it superior to his own and all others. The chief claim made for it was that it made a permanent record, which was invaluable. They believed the claim to be valid, and do today; for, while we soon drifted away from the registers and adopted sounders instead, the Morse system, all over Europe today, is worked with registers. Not our clumsy embossing point style, but a beautiful glass-enclosed, ink-writing register, the armature of which moves so delicately that lines of one hundred miles in length are worked without relays, the main current working the register direct.

Now let us return to the Cooke and Wheatstone. The use of a bell magnet for a call, as we have seen, shut out the Morse, and, of course, perpetuated that of Cooke. Improvements were constantly made until four wires were dispensed with, and the single needle style that I have described came into use universally.

As the insular position of the English people had developed them into the first maritime nation of the earth, they soon saw how beneficial telegraphic intercourse would be with their colonies and the distant markets of the world visited by their shipping. Capital was plentiful, and forthwith experiments innumerable were made to connect England by cable with foreign countries. The Cooke and Wheatstone dial was the type of instrument clearly. Nothing like the Morse electro-magnet form would do, and electricians laboured unceasingly, until the Thomson cable galvanometer solved the problem, and to-day there is no inhabited land so remote that English cables do not reach it, and the galvanometer needle does not flash its dot and dashes.

And what of the Morse? Improved to the utmost as a recording telegraph by the Europeans, it is in use everywhere, even in the British islands; and the Cooke and Wheatstone, having fulfilled its mission as the progenitor of the world's cable system, is now relegated to use upon unimportant commercial lines and railroad wires.

In America the original Morse was discarded at an early date, and the sounder took its place. The Morse, unlike the Cooke, is an elastic system, and while the English, anxious to connect their little islands with the outside world, were solving the cable problem, the Americans were equally industrious in their efforts to cover their vast continent with land wires. The great distances between important cities necessitated an immense expenditure, and the problem for them to solve was how to increase the capacity of existing wires.

The incomplete duplexes of Europe tried and abandoned were taken up, improved upon, made successful, and forthwith incorporated into the Morse system. The quadruplexes followed, and the result is seen to-day in the best land line system in the world.

Meanwhile, an adjunct to rapid telegraphy was developed from the chemical system of Bain. Introduced into the United States,

* From the *Journal of the American Electrical Society.*

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it was driven out by the Morse patentees. Almost wholly abandoned by the inventor, it was taken up by various parties in this country and in Europe, and developed into an automatic system, thus making it what Bain himself intended, by perforating a strip of paper with the dots and dashes composing the message, and using this perforated paper in lieu of a key.

In America, although very rapid sending has been accomplished by this system, it has not been adopted, as the work of perforating and copying is too expensive.

But in England it is extensively used. Press report is perforated on a strip—report lines of equal resistances are grouped or "bunched" together, several on one transmitter, and the same paper strip is passed through one transmitter after another in succession. Thus one perforation supplies for many transmissions.

To sum up the case, then, the bell magnet of Cooke and Wheatstone drove Morse out of England and perpetuated the needle system, from which resulted the cable system of the world, while the ignorance of Professor Morse of what was being done elsewhere induced him to go on and develop the land system of the world, and the chemical researches of Alexander Bain have resulted in the development of an automatic system which is doing splendid service in Europe. To such trifles, then, does the world owe the electrical successes of to-day.

And now these systems, having reached their development, are blending harmoniously in England, under the fostering care of the energetic and intelligent managers of their telegraph lines. Already the quadruplex and the Wheatstone automatic are united, and while the "Morse side" is working duplex, the "polar side" is used as an automatic at a high rate of speed.

Had Morse known what was being done in Europe, he would, in all probability, have abandoned his efforts. And afterward, had his system been introduced into England, cable telegraphy would, at least, have been far behind its present development.

And therefore, crude as my pair of needle instruments are—inefficient as they seem—I cherish them with the same feelings that induces the railway company in England to preserve and cherish Stephenson's first locomotive—an awkward looking affair of itself, but the progenitor of the perfect locomotives of to-day.

LITERATURE.

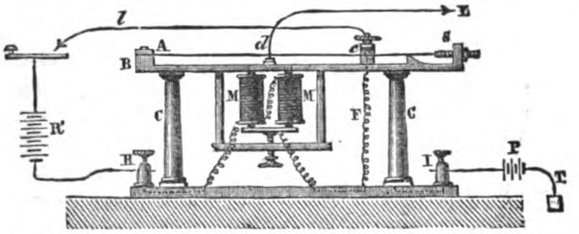
The Telephone, the Microphone, and the Phonograph. By Count Th. du Moncel. C. Kegan Paul and Co.

Le Téléphone, le Microphone, et la Phonographe. Par le Comte Th. du Moncel. Hachette et Cie.

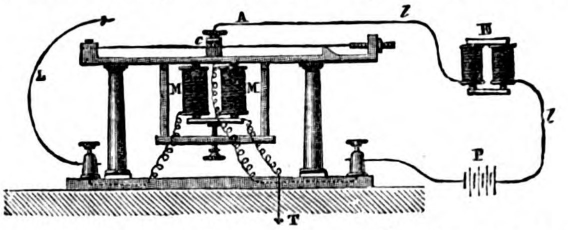
[Third Notice.]

The possibility of duplex working led Gray and Bell to the invention of speaking telephones. The principles of simultaneous transmission are briefly described, and illustrated by a more extended description of various systems, such as Lacour's, Gray's, Varley's, &c. The following is our author's description of Gray's system :—

"Each sender represented in the figure consists of an electro-



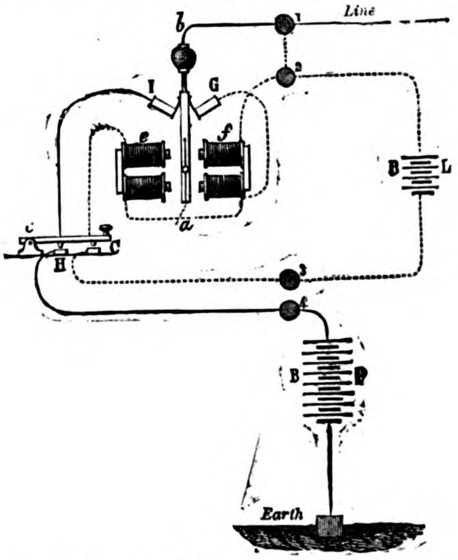
magnet, M M, resting below a small copper tablet, B S, in such a way that its poles pass through this tablet and are on a level with its upper surface. A steel plate, A S, is fixed above these poles. Its tension can be regulated by means of a screw, *s*, and another screw, *c*, is placed on the plate, and is in electric communication with a local battery, R¹, by means of a Morse key. Below the plate A S there is a contact, *d*, connected with the line wire L. This contact is met by the plate at the moment of its attraction by the electro-magnet, and breaks the current of a line battery, P, which acts on the receiver of the opposite station. Finally, the electric communication established between the local battery R¹ and the electro-magnet, as may be seen in the figure, produces vibrations in the steel plate A S at each lowering of the key, as in the case of ordinary vibrations—vibrations which, with a suitable tension of the plate and a given intensity of the battery R¹, can produce a definite musical note. Moreover, since at each vibration the plate A S meets the contact, discharges of the line current take place through the line L and react on the receiving instrument, causing it to reproduce exactly



the same vibrations as those of the sending instrument. The receiving instrument represented in figure exactly resembles the one we have just described, except that there is no contact *d* below the vibrating plate A S, and the contact *c*, instead of communicating with the line wire, is in electric connection with a register, E, and a local battery P. It follows from this arrangement that, when the plate A S vibrates under the influence of the broken currents passing through the electro-magnet M M, similar vibrations are sent through the register; but if the electro-magnetic organ of this register is properly regulated, these vibrations can only produce the effects of a continuous current, and hence the length of the traces left on the instrument will vary with the duration of the sounds produced. In this way the registration of the dashes and dots which constitute the signs of the Morse vocabulary will be effected. . . ."

In a new arrangement, exhibited at the Paris Exhibition, 1878, Mr. Gray considerably modified the way of working the various electro-magnetic organs which we have just described. In this case the plates consist of tuning-forks with one branch kept in continual vibration at both stations, and the signals only become perceptible by intensifying the sounds produced. This arrangement follows from the necessity of keeping the line circuit always closed for multiplying transmissions of this nature, so as to react with pulsatory currents, which are alone able, as we have already seen, to retain the individual character of several sounds simultaneously transmitted.

Under these conditions, the sender consists, as we see in figure,



of a bar tuning-fork, *a*, which is grooved for the passage of a runner heavy enough to tune the fork to the desired note, and it oscillates between two electro-magnets, *e* and *f*, and two contacts, I and G. The difference of resistance in the electro-magnets is very great; in the one, *f*, the resistance is equal to 2¾ miles of telegraphic wire, in the other it does not exceed 440 yards. When electric communication is established, as we see in the figure, the following effect takes place. Since the current of the local battery through the two electro-magnets is broken by the rest-contact of the Morse key H, the plate *a* is subject to two contrary actions; but, since the electro-magnet *f* has more turns than the electro-magnet *e*, its action is preponderant, and the plate is attracted towards *f*, and produces a contact with the spring G, which opens a way of less resistance for the current. Since the current, then, passes almost wholly through G, *b*, 1, 2, and B, the electro-magnet is now able to act; the plate *a* is thus attracted towards *e*, and, by producing a contact on the spring 1, it sends the current of the line B P through the telegraphic line, if the key H is at the same time lowered on the sending contact; if not, there will be no effect in this direction, but since the plate *a* has left the spring G, the first effect of attraction by the electro-magnet *f*

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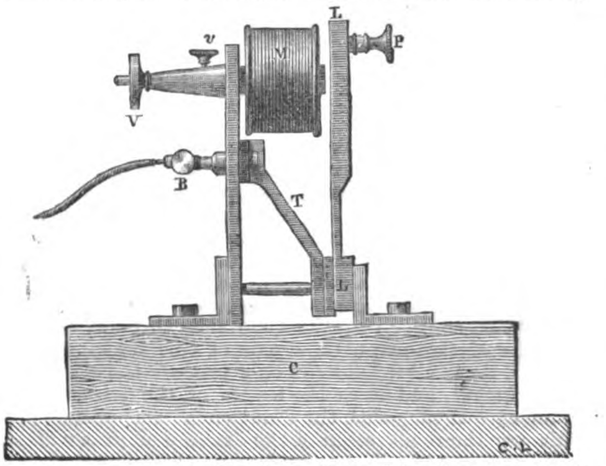
will be repeated, and this tends to draw the plate again towards *f*. This state of things is repeated indefinitely so as to maintain the vibration of the plate, and to send out signals corresponding with these vibrations whenever the key H is lowered. The elastic nature of the plate makes these vibrations more easy, and it ought also to be put in mechanical vibration at the outset.

The receiver represented in figure consists of an electro-magnet,



M, mounted on a sounding box, C, and having an armature formed by a tuning-fork, L L, firmly buttressed on the box by a cross-bar, T. There is a runner, P, on the armature, sliding in a groove, which makes it possible to tune the vibrations of the tuning-fork to the fundamental note of the sounding box C, which is so arranged as to vibrate in unison with it. Under these conditions, the box as well as the tuning-fork will act as an analyser of the vibrations transmitted by the currents, and may set the register at work by itself reacting on a breaker of the local current. To obtain this result, a membrane of gold beater's skin or parchment must be stretched before the opening of the box, and a platinum contact must be applied to it, so arranged as to meet a metallic spring connected with any kind of register or a Morse instrument when the membrane vibrates.

A chapter is given on the phonograph, and in an appendix the author describes various microphonic speakers, altogether making it, as we have before said, the best popular work on these subjects.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

Report of the Directors to be presented to the Fourteenth Ordinary General Meeting, to be held at the Terminus Hotel, Cannon-street, on Monday next, July 14:—The Directors submit the accounts and balance sheet for the six months ended 31st March, 1879. The Company's revenue for this period amounted to £235,077 14s. 5d., from which is deducted £67,953 3s. 4d. for the ordinary expenses of the Company, and £23,935 18s. 7d. special expenditure during the half year, £329 6s. 8d. for bad debts, and £1,949 16s. 3d. for income-tax, leaving £140,909 9s. 7d., which, together with £3,433 3s. 4d. brought forward from the preceding half year, gives a balance of £144,342 12s. 11d. From this balance £14,480 15s. has been paid for interest on debentures, and £20,560 6s. 10d. is required for dividend to 31st March, 1879, at 6 per cent. per annum on the preference shares. The directors have during the half year paid an interim quarterly dividend of 1¼ per cent. on the ordinary shares. They now recommend the declaration of a final dividend for the year ended 31st March, 1879, of 2s. 6d. per share, payable 15th instant, making, with the three previous payments on account, a total dividend for the year of 5 per cent. on the ordinary shares, and that the balance, £16,876 11s. 1d., be carried to the reserve fund, which will then amount to £175,512 16s. 9d. The several sections of the Company's cables continue in good working order. With a view of reducing the cost of repairs, the directors have had a new steamship built, of small tonnage, with which cable repairs can be effected in shallow water, as experience has shown that the greater number of interruptions to the Company's cables occur near the shore. An agreement has been entered into between the Lords Commissioners of H.M. Treasury, the Eastern Telegraph Company, and the Telegraph Construction and Maintenance Company, and subsidiary contracts with the Colonial Governments of the Cape of Good Hope and Natal, the Portuguese Government, and the Sultan of Zanzibar, for the establishment of submarine cable communication between this Company's station at Aden and Natal, *viâ* Zanzibar, Mozambique, and Delagoa Bay. The Telegraph Construction and Maintenance Company have engaged to manufacture and lay the cables and provide a suitable maintenance ship at a cost of £950,000, and the work is to be completed by December next. The following subsidies are to be paid by the respective Governments:—H.B.M. Government £35,000, Cape Colony £15,000, Natal £5,000, Portugal £5,000; total £60,000. The subsidies are payable irrespective of the amount of traffic receipts, except that the Portuguese subsidy is to be reduced to one-third when for two years the traffic has reached 100 through messages (20 words each) per day, and is to cease when for two years 200 such messages per day have been obtained. The payments are to continue for 20 years, subject only to suspension for any period exceeding three consecutive months, during which the section from Zanzibar to Natal is not in working order, and six consecutive months as to the section from Aden to Zanzibar. The agreements with the respective Governments will be submitted to the meeting. As the Board consider it inexpedient that the Eastern Company should take the entire responsibility of this undertaking, it is intended to form a separate company, to be called the Eastern and South African Telegraph Company, with a share capital of £400,000, and mortgage debentures for £600,000, but as the entire management and working of the cables will be in the hands of the Eastern Company, and the traffic will pass over their wires, from Aden, the new lines will practically be an important addition to this Company's system, and in consideration of the advantages which will be derived therefrom, it has been agreed, subject to the approval of the shareholders, that £200,000 of the share capital, and, if necessary, a portion of the debentures shall be subscribed by this Company, and a rebate be given upon the traffic obtained by the Company from the new lines. As the debentures are to be paid off by means of an accumulative sinking fund, the Eastern Company will thus obtain half the reversionary property in the new lines, whilst the Company's holding in the share capital will give them an effective control. Particulars of the estimated revenue and other details will be given at the meeting. Resolutions will be submitted to the meeting authorising the Board to do what is necessary on behalf of this Company for carrying the proposed arrangements into effect.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices July 9.		Business Done Week Ending July 9. Highest.	Lowest.
Anglo-American	54¾,	55¼	55½	54¾
Do. "B"	85,	¼	85½	84½
Do. "A"	26¾,	27	27¼	26⅝
Brazilian	6¾,	7	6 15-16	6 13-16
Cuba	8¼,	¾	8⅝	8¼
Do. Ten per Cent. Preference	16,	17	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	10¾,	11¼	11⅛	11
Direct United States	10⅜,	⅝	10¾	10⅝
Eastern	7 11-16,	13-16	7⅞	7 11-16
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	102,	104	103½	102¾
Do. Six per Cent. Preference	11¾,	⅞	11¾	11¾
Eastern Extension	7¾,	⅞	7¾	7¾
Do. Six per Cent. Debenture	108,	111	—	—
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4 13-16,	15-16	4⅞	4¾
Do. Six per Cent. Preference	10 13-16,	15-16	10⅞	10¾
Great Northern	8⅛,	⅜	8⅜	8 3-16
Indo-European	21,	22	21	21
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	8¾,	9¼	9¼	9
Reuter's	9,	10	9½	9¼
Submarine	225,	235	230	230
West India and Panama	1½,	¾	1½	1½
Do. Six per Cent. Preference	7⅞,	8⅛	8 1-16	8
Western and Brazilian	3,	½	3½	3½
West. Union Seven per Ct. 1st Mt.	115,	120	—	—
Do. Six per Cent. Sterling	106,	108	—	—

TRAFFIC RECEIPTS FOR JUNE, 1879.

Companies.	June 1879.	June 1878.	Incrse.	Decrse
Cuba Submarine Company	2,400	3,175	—	775
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	15,000	—	—	—
Eastern Extension Telegraph Company	26,485	23,269	3,216	—
Eastern Telegraph Company	36,635	31,118	5,517	—
Great Northern Telegraph Company	19,618	—	—	—

THE EASTERN TELEGRAPH COMPANY (LIMITED).

NOTICE IS HEREBY GIVEN, that the FOURTEENTH HALF-YEARLY ORDINARY GENERAL MEETING of the EASTERN TELEGRAPH COMPANY (LIMITED) will be held on MONDAY, the 14th JULY, 1879, at TWO O'CLOCK in the afternoon, at the Terminus Hotel, Cannon-street, London, when the Report and Accounts of the Directors will be presented, a Dividend declared, and the ordinary business of the Company transacted.

RESOLUTIONS will be proposed, authorising the Board to carry into effect the arrangements referred to in the Report respecting the new Telegraph Lines from Aden to Natal.

NOTICE is also given, that the Registers of Transfers will be closed from the 7th to the 14th July, both days inclusive.

By order of the Board,

London, 5th July, 1879. GEORGE DRAPER, *Secretary*.

A LADD'S DYNAMO-ELECTRIC MACHINE, one man-power, in perfect condition, to be DISPOSED OF for half price. Admirably adapted for any institution or laboratory where powerful currents are occasionally required.—Address, A. D., 6, Akerman-road, Brixton.

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(For use preferably with Chromic Acid or Nitro-Chromate Solution.)
This battery emits no fumes, and has an electro-motive force superior to that of Bunsen.
PRICE . . . 10s. and 12s. 6d. per Cell.
For information as to solutions to be used &c., apply to Mr. L. A. Davies, 6, Akerman Road, Brixton.

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NOTES.

Cyprus.—The Eastern Company's system is now extended to Famagusta and Phaphos.

Telegraph Construction and Maintenance Company.—The directors of the Telegraph Construction and Maintenance Company have declared an interim dividend of 12s. per share, or at the same rate as for the corresponding period last year.

Telephone Diaphragms.—According to M. Decharme, who has made a number of experiments with vibrating plates of glass and metal, the diaphragms of telephones should be fixed at the centre, instead of at the circumference, in order to obtain the greatest sensitiveness to external vibrations.

Lightning Conductors.—Mr. Richard Anderson, member of the Society of Telegraph Engineers, has nearly ready for publication a scientific and practical treatise on lightning conductors. The subject is an important one, and Mr. Anderson's experience in this department of applied science renders him a good authority in such matters. We await the publication with interest.

The Law of the Telephone.—The results arrived at by the investigation of Mr. Hermann and Professor Helmholtz are:—(1) In the telephonic circuit the tone is in general altered; (2) The phase displacement that occurs during the telephonic transit is not a constant quantity, its amount changes with the constitution of the path of the current, and depends on the number of vibrations; (3) In certain cases, however, the amplitude of the induced current becomes independent of the vibration number n, and thus the tone of the exciting sound is unchanged.

Anglo-American Telegraph Company.—At a meeting of the board of directors of the Anglo-American Telegraph Company, Limited, held on the 11th inst., it was resolved (after reserving £37,500 for the renewal fund) to declare an interim dividend, for the quarter ending the 30th June, of 1¼ per cent. on the consolidated stock, and 2¼ per cent. on the preferred stock, both free of income tax, and payable on the 1st of August to the shareholders registered on the 1st of July. This leaves an estimated balance of £10,000 to be carried forward to next quarter's account.

Thunderstorms.—A heavy storm broke over Chester on Sunday afternoon and at night. Flashes of blue forked lightning came in rapid succession, followed by loud peals of thunder and torrents of rain. Great damage was done by the rain. When the storm was at its height the lightning struck a peach house attached to Hoole Hall, the residence of Mr. Arthur Potts, stunning Taylor, the gardener. At Liverpool the lightning struck and shattered a large cross on the schools connected with St. Francis Xavier's Roman Catholic Church. The *débris* fell into the school yard, but no one was hurt.

Eastern Telegraph Company.—The report of the directors of the Eastern Telegraph Company, Limited, for the six months ended with March, 31, shows a revenue of £235,078, and a balance of £144,343, from which have to be deducted the interest on debentures and the preferential dividend. An interim quarterly dividend of 1¼ per cent. was paid on the ordinary shares during the half year, and the directors now recommend a final distribution of 2s. 6d. per share, making a total dividend of 5 per cent. for the year ended with March 31. A balance of £16,876 is carried to the reserve fund, which now amounts to £175,513.

Dr. Hooke's Telegraph.—In 1684 Dr. Hooke proposed a kind of mechanical telegraph which, however, was not carried into operation. He prepared as many different shaped figures in wood, as, for example, squares, triangles, circles, &c., as there are letters in the alphabet. He exhibited them successively in the required order, from behind a screen, and proposed that torches or other lights, combined in different arrangements, should supply their place at night. Twenty years later Amontous, of Paris, exhibited some experiments before the royal family of France and the members of the Academy of Science, showing the practicability of the system.

Another "Daily News" Telegram.—Mr. Edison has partially overcome the obstacle to his electric light offered by the high price of platinum. His lamps, instead of costing several dollars a piece, as at first, can now be made of an alloy of platinum with inferior metals, so as to cost only fifty-six cents. He announces that he can now produce the spiral coil for incandescence at a price which all who use gas can easily afford, and that his efforts to find platinum are only induced by the desire to reduce the cost of burners still further. [This is good for the Anglo-American Company, and we trust, for the sake of the shareholders, that "Our Own Correspondent" will send a telegram every day, but the information here is, from a scientific point of view, of an extremely doubtful character.]

The SS. Retriever for Cable Repairing.—The Eastern Telegraph Company, after a long experience, has ascertained that the majority of faults interrupting cable work, occur in the shore ends, and has, therefore, built and equipped a beautiful little steamer, having the following dimensions:—Length, 174ft.; beam, 26ft.; depth of hold, 14ft.—for the purpose of effecting this class of repairs. This company has no less than eighty-two shore ends in its system, and the expenses of keeping a large ship moving from place to place is enormous—the insurance itself costing something like £4,000 a year. It is hoped that by the use of this small vessel to make repairs of a minor nature a saving may be effected, as the normal expenses of such a ship are only about one-fourth of those of the large vessels usually employed.

Lomond.—Who was the Mr. Lomond spoken of by Young in his work, "Travels in France in 1757?" The paragraph runs as follows:—"Mr. Lomond has made a remarkable discovery in electricity. You write two or three words upon paper; he takes them with him into a chamber and turns a machine in a cylinder case, on the top of which is an electrometer having a pretty little ball of pith of a quill suspended by a silk thread; a brass wire connects it to a similar cylinder and electrometer in a distant apartment, and his wife, on observing the movements of the corresponding ball, wrote the words which it indicated. From this it appears that he had made an alphabet of movements, and as the length of the brass wire made no difference you could correspond at a great distance—as, for example, with a besieged city, or for purposes of more importance."

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A New Current Breaker.—A simple form of contact breaker is described by Dr. F. Niemoller. To the middle of a wire stretched horizontally is attached a platinum point which touches the surface of mercury held by a small vessel. The current passes through the wire, and over that part of the wire through which the current passes when all the apparatus in its normal state is a small magnet. This magnet, acting on the current, causes vibrations in the wire, and so breaks and makes contact. The number of vibrations can be readily modified by changing the length of the wire, and as high a number as 1,000 breaks per second can be obtained. By passing an intermittent current over the wire, it can be set in vibration without the intervention of mechanical means. This happens when the fundamental note of the string is in unison with the pitch of the breaker.

The Illumination of Gases by Electric Discharges.—Professor Wiedemann, by means of a small calorimeter in connection with a peculiarly-arranged exhaustion tube, has made some experiments on the heat communicated to a gas under different pressures. The temperature of the gas under experiment was at first 20° C and reached a maximum of from 80° to 90° by means of the discharges from a Ruhmkorf coil. Even at this temperature the gas was brilliantly illuminated; and the temperatures of 62°—70° was not found to be the lowest at which the gas was illuminated. The illumination at such low temperatures Professor Wiedemann thinks is produced by an exaltation of the living force of the oscillatory movements of the ether envelopes. The electrical discharge calls forth this action independently of the increase of molecular movement which results from the increase of temperature.

The Electric Light in Mining.—The first electric light employed in the Western mines of America was placed on the Deer Creek placer claim of the Excelsior Water Company at Smartsville, Nevada, on the 10th of last April. A 12,000 candle power Brush machine was put in operation, and three lights of 3,000 candle power each were placed in prominent positions upon the claim. Although the night was very dark, the lights shed a brilliant light around, and enabled the miners to work as readily as during the day. Until this experiment, the mines had to shut down during the night, but now the company expects to work both night and day. Nevada and Yuba counties have many hydraulic mining companies, and several of them have announced their desire to use the new light if the Excelsior Company is thoroughly satisfied with their machine. The cost of lighting the claim by electricity is said to be 16 cents. an hour.

Electric Candles.—Up to the present time all electric candles in use have been made from pure carbon or carbon mixed with other substances, such for example as kaolin or plaster of Paris, which all have the great disadvantage of burning too quickly away, and producing more or less a flickering light. They, therefore, require controlling mechanism to regulate the distance of the candles. Mr. S. Cohne, of Gracechurch-street, proposes to mix a quantity of ultramarine, blue or green, with so much silicate of soda or of potash in solution as is sufficient to produce a paste, which paste he forms into any desired shape or form. He then presses it by a mould into the exact form required, either by hydraulic pressure or otherwise, and has it dried and heated by the fire, whereby all the moisture evaporates, the sulphur burns away, and all the organic matter which may be in it becomes carbonised. When put into use the resistance and the current in the arc are to a very great extent less varying, and controlling mechanism to regulate the distance of the candle is nearly unnecessary, because the candle is consumed very slowly comparatively to others in existence. Further, less consumption of energy is required for his candle, and therefore the divisibility of the electric light becomes easier. For the purpose last named, the divisibilty of the light, he draws a copper or platinum wire through or within his candle, whereby the conductibility is greatly increased; thus very little consumption of energy takes place, and the problem of the divisibility of the electric light is solved. [We are not sure that the inventor understands the problem of the divisibility of the electric light, and we do not think the means adopted has solved the problem]. What is claimed is the use of ultramarine, blue or green, either alone or combined with the above mentioned materials; or instead of using the ultramarine as manufactured, he uses the different substances which together produce the article known as ultramarine. He wishes it to be understood that it is the ultramarine blue or green, or the materials which united produce the ultramarine, which he claims for the preparation of the electric candle as described, either with or without a copper or platinum wire.

The Effect of Telephonic Transmission upon Sounds.—At the *Société Française de Physique*, M. Bouty described the researches of MM. Dubois-Reymond, Hermann, Weber, and Helmholtz, on the modifications produced by telephonic transmission in the intensity and character of sounds. According to Dubois-Reymond, deep sounds should become weakened more than acute sounds, whence a certain alteration of *timbre;* at the same time all sounds, whatever may be their position in the scale, would be retarded by a quarter of a wave. M. Helmholtz, on the other hand, by a theory which is apparently more complete, finds that all sounds are weakened in the same ratio, and that the variation in character should be very slight. Experiments to decide the question were undertaken by M. Kœnig. He substitutes two tuning-forks, A and B, for the membranes of two telephones connected together, and causes A to vibrate by means of a bow. B immediately commences to vibrate; and we may, either by observing successively, by means of an optical comparer, the vibrations of A and B, or by arranging A and B as in the well-known experiment of M. Lissajous for the composition of rectangular vibratory movements, measure the difference in character of the two tuning forks, which is found to be exactly equal to quarter the length of a wave. An experiment on complex sounds was made by employing a ut_1 tuning-fork, and ut_4 tuning forks, so as to produce simultaneously the sounds 1 and 8 in front of the bar of a telephone; the difference in character of the sound 8 at the manipulating and receiving telephones was again found equal to one-quarter of a wave. The theory of Doubois-Reymond is, therefore, more in accord with experiment than that of M. Helmholtz. But the problem relative to telephonic transmission appears to be extremely complex. Some new experiments of M. Kœnig establish: 1. That a tuning fork vibrating in front of the bar of a telephone of which the circuit is closed, comes to rest in a much shorter time than if it vibrated freely; 2. That the sound of a tuning fork becomes more and more lowered as the distance between it and the bar of the telephone is diminished, and as the amplitude of vibration becomes smaller. A complete theory should take these phenomena into account.

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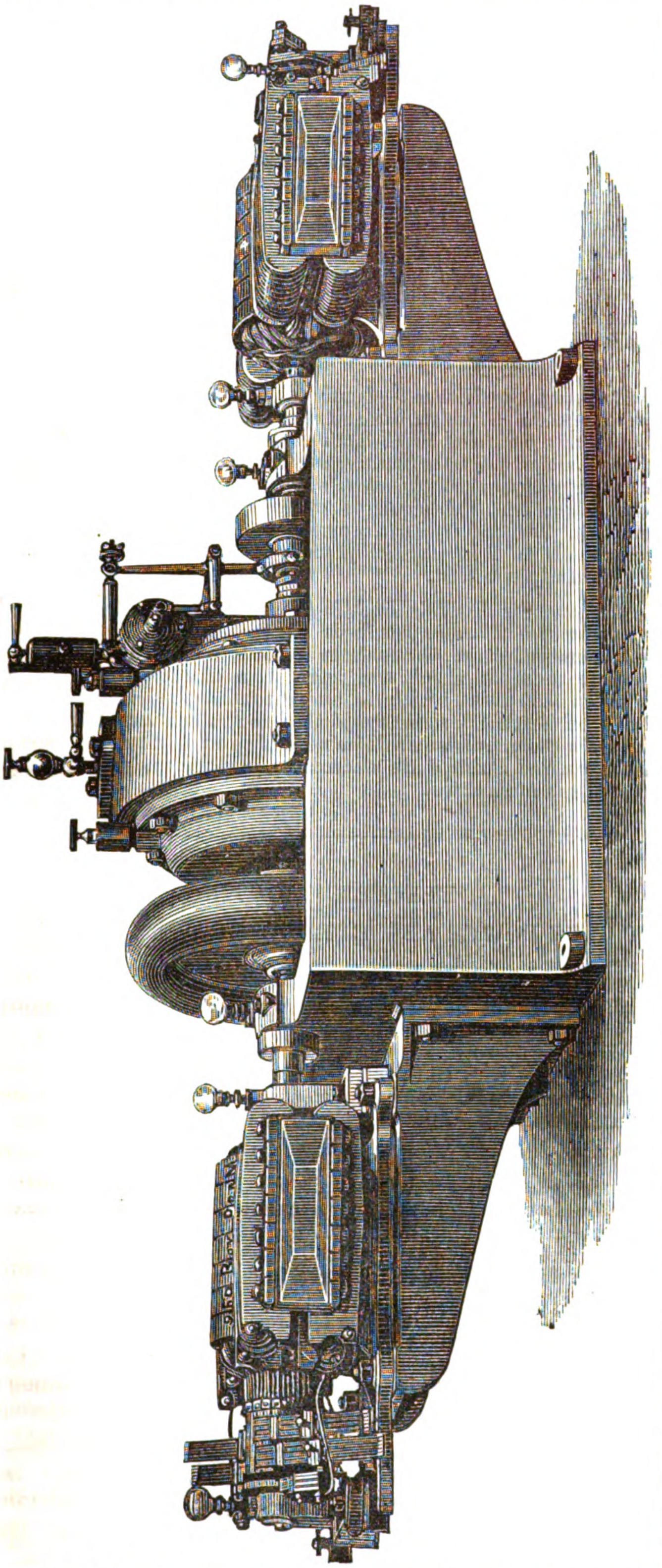
BROTHERHOOD'S THREE-CYLINDER ENGINE FITTED TO SIEMENS' ELECTRIC MACHINE.

The above illustration shows the most recent adaptation of the now well-known Brotherhood three-cylinder engine to a special purpose, that of driving a pair of dynamo-electric machines. For this purpose they are specially suited, as the crank shaft at



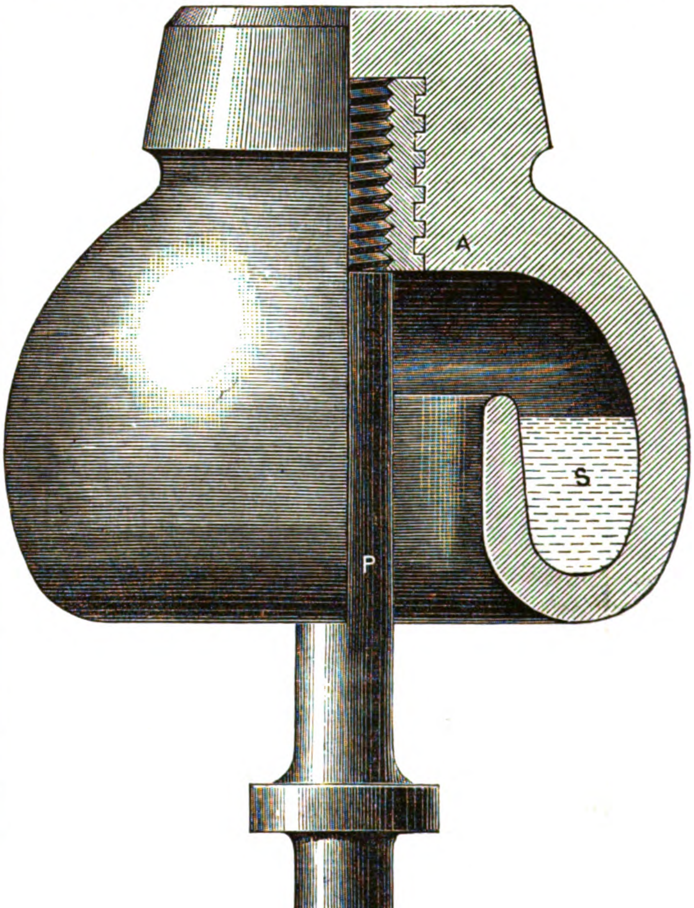
each end is free for connection, and the single action of the three cylinders secures that uniformity of revolution of the shaft, without any back lash or shock of any kind, which is so essential for the efficient working of dynamo-electric machines. One of the engines and pair of machines here illustrated was shown at the recent *conversazione* of the Society of Telegraph Engineers, and attracted much attention. The engine was in this case worked by the Siemens' machines, which it is intended to work, the machines being for the time converted into electro-dynamic motors supplied by electricity from other larger machines. Our illustration is from the *Engineer*.

THE CONVERSAZIONE OF THE SOCIETY OF TELEGRAPH ENGINEERS.

Among the apparatus exhibited at South Kensington we noticed some that was new, and some that has not been described in our columns. We shall therefore as opportunity offers refer to these exhibits.

JOHNSON AND PHILLIPS' EXHIBITS.

Patent Fluid Insulators.—(See engraving.)—The patentees interpose between "Line" and "Earth" an insulator containing a fluid which will not support a *film of dust or moisture upon its surface.* In this way "surface leakage" is quite prevented, a very important feature in damp and marshy districts, along the sea coast, where insulators soon become coated with a conducting film of salt, or in the neighbourhood of towns or manufacturing districts, where carbon is deposited upon the surface of the porcelain. Messrs. Johnson and Phillips exhibited an insulator which had been fixed for ten months over a chimney, and was perfectly coated with carbon all over. Before testing it was thoroughly wetted with



a jet of steam, when its insulation was found to be perfect, while an ordinary insulator fixed beside it gave "dead earth." There is no doubt, say the makers, that by care a land line might be made in this way to give an insulation quite equal to that of a gutta percha core, a very important fact in connection with duplex working, where every shower will greatly alter the resistance of the "Line," when insulated with the ordinary insulators. Colonel Champain is giving these insulators a trial on the Mekran Coast, and has spoken well of the invention. The General Post Office also, and the French telegraph authorities are giving them a trial.

Steam Hauling Machine for general Deck Use on board a Steamer engaged in Laying or Repairing Cables.—This machine consists of a sheave, having a deep groove for the reception of the cable, which is coupled to a spur wheel on the same shaft. Into the

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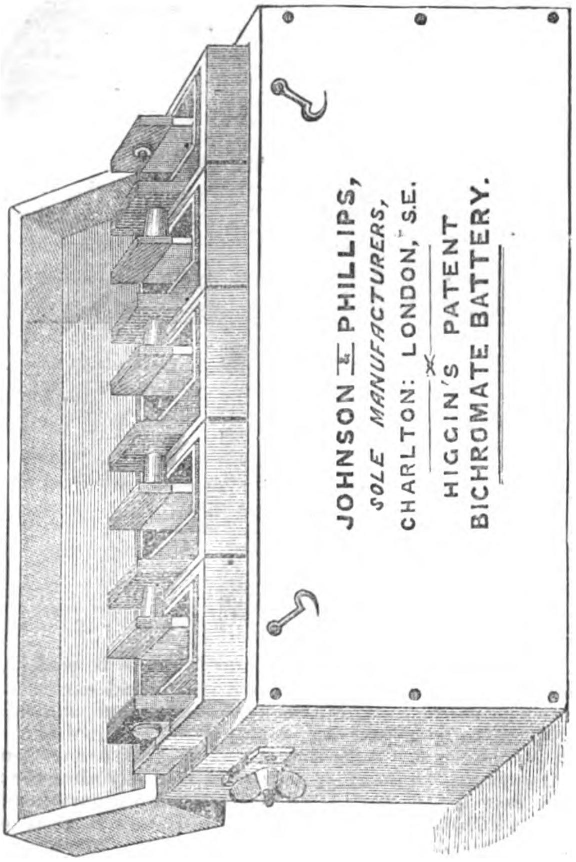
spur wheel gears a small pinion, which is keyed to the shaft of a 3-cylinder engine. The frame is a box-casting in one piece, and is mounted on four small wheels, so that it can be readily moved about a ship's deck by one or two men. The engine is governed by one lever, and can be instantly stopped or reversed. A jockey wheel with a weighted lever is used to keep the cable pressed firmly into the grooved sheave. The jockey wheel is exactly one yard in circumference, and its shaft actuates a revolution indicator, so that the number of miles of cable passed through the machine can be noted at any time. These machines are intended to be coupled to the deck steam pipes of the vessel by means of a length of flexible steam hose, which is supplied with the machine. The Eastern Telegraph Company have lately supplied their principal stations in the Mediterranean with several of these machines, which are well adapted for the repairing expeditions that are constantly necessary.

Cutting and Holding Grapnel.—This grapnel was used by the Telegraph Construction and Maintenance Company in the repairs to the deep sea section of the Brazilian Submarine Company's Cables. It was successful in grappling the cable on this occasion in a depth of about 2,000 fathoms, and, after cutting, raised one of the ends to within a few fathoms of the surface of the water. The suspended end of the cable then, unfortunately, broke a few fathoms from the grapnel, leaving a short piece of cable firmly gripped by the holding apparatus. The jaws containing the holding clips are of cast steel. The holding clips are of forged steel. The cable, after being hooked by the prongs A, tears through the protecting covering B (of sheet india rubber), and falls into the serrated clip beneath. As the pressure on the cable increases this clip shears through the lead bolt C, and, descending into the tapering jaws, causes the serrated surfaces of the clip to close upon it and so hold it. On the other hand, as the pressure comes on the other end of the cable, it is cut through by the V knife D, and falls to the bottom.

Higgins' Patent Bichromate of Potash Battery.—The chief peculiarities of this battery are that in it, in making a reliable connection, a disc of non-oxydizable alloy (platinum iridium) is employed, and all possibility of that oxidation of the surface in contact with the carbon which invariably takes place when baser metals, such as copper, lead, nickel, antimony, &c., are used, is



avoided. Then the carbon plate is rendered non-porous by a special treatment, preventing the exciting fluid of the battery rising in the plate by capillary action, and also preventing the absorption of the exhausted fluid. The plate is thus rendered much less liable to polarisation, and depolarisation takes place much more quickly. Great care is taken in selecting the metal for the zinc plates, and it is subjected to a special treatment which prevents local action, thus insuring that the materials be consumed in useful work only. The cost of maintenance of this battery, as compared with sulphate of copper batteries, is said to be for closed circuits about one-fourth, and for open circuits about one-eighth. The following instructions are given as to the fluids used :—For the carbon cell : Add to a saturated solution of bichromate of potash about one-fifth part by measure of ordinary sulphuric acid.—For the zinc cell : To thirty parts of water by measure add one part by measure of sulphuric acid; or, for needle circuits, common salt and water may be used.

Resistance Box and Bridge, with Sliding Contacts.—This box was designed chiefly with the idea of being a convenient arrangement for localising faults. In testing a fault which polarises very quickly it is important to keep the eyes fixed on the scale of the galvanometer so as to see the exact instant when a balance is obtained, but with the ordinary resistance coils, one has to look from the scale to the resistance coil in order to put in or take out plugs, while in this box it is only necessary to turn the handles, which slide a pointer over platinum contacts, which are protected from dust by a glass cover. The bridge arrangement consists of eight coils—viz., 10, 100, 1,000, and 10,000 units on each side, which give the instrument a wide range—and there is in addition a plumbago resistance of one megohm, the ends of which are brought to two separate terminals.

Plumbago Resistances.—Some of the first ones, made many years ago on vulcanite, have since been found not to stand well, but a very permanent resistance may be made on glass, the surface of which has been finely ground so as to take a pencil mark. Having well marked the glass with a pencil, and dusted off all free plumbago, the whole is carefully varnished with shellac varnish. The makers have a resistance of 1·08 megohms which was made in this way six years ago, and which has remained wonderfully constant.

Carbons for Electric Lighting.—A special factory for the manufacture of these has been constructed, and, by great care in the manufacture, the makers are led to believe that they can produce a carbon which will burn in a steady uniform manner without that noise which is at present so objectionable. We have on several occasions said that good work was to be done in this direction, and we shall be very pleased to find that Messrs. Johnson and Phillips are successful in their endeavours to perfect the manufacture.

ELECTRIC LIGHTING.

MOTIVE POWER ABSORBED BY GRAMME MACHINES.

BY HYPPOLYTE FONTAINE.*

Before estimating the motive power absorbed by magneto-electric machines in producing a given quantity of light, it is necessary to know: 1, the unit of light; 2, the position of the observer relatively to the electric focus.

In France we take as the unit of light the intensity of a Carcel lamp, having a wick 3 centimetres in diam. and burning 42 grammes of purified colza oil per hour, with a flame 4 centimetres in height. This is termed the *Carcel bec* (or *burner*).

In England they take as unit the intensity of a spermaceti candle (London standard sperm candle), which, with a flame 45 millimetres in height, burns 7·77 grammes per hour.

In Germany they have generally adopted as unit the intensity of a paraffin candle 20 millimetres in diam. burning with a flame 50 millim. high.

Experience has shown that 1 Carcel bec gives a light equal to 9 English candles and to 7·6 German candles.

The measurement of the intensity of an electric focus has been up to the present time performed in various ways according to the object kept in view by the operator. In lighting workshops, it is customary to measure the light as sent horizontally in every direction; in the case of lighthouses, the power of the focus is estimated when the whole of the light, as far as possible, is sent in a given direction by the reflector. Of course, the results thus obtained are in no way comparable.

When we have to estimate the light produced by incandescence, or by an arc due to alternating currents, the arrangement may be that in which the photometer, the Carcel lamp, and the electric focus are in the same horizontal plane. Results are thus obtained which are comparable to those found when the intensity of oil lamps is measured. But when we have to deal with a regulator with vertical carbons, worked by a machine furnishing a con-

* Translated from the *Revue Industrielle.*

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tinuous current, this arrangement should not be adopted; for it allows a considerable advantage in favour of the Carcel lamps.

The flames of Carcel lamps are, in fact, transparent, and they are so constructed as to give their maximum of intensity in the horizontal plane. This is not the case with the electric light produced by continuous currents. The hypothesis which assimilates this to a small luminous sphere a centimetre in diam. is not in accord with reality. The upper carbon becomes hollowed out, the lower one becomes pointed; the light emanates from a small cup applied against an opaque body, and the form and position of which vary with the intensity and the direction of the current. The quantity of light received by the observer depends upon the angle at which he views the luminous cup; and, if we consider a circle described in the plane of the carbons, with the cup as centre, each point of the circumference of this circle will receive different quantities of light. To obtain comparable measurements, it is necessary either to take the mean of the measurements obtained over the whole of the circumference, as well in the case of the Carcel lamp as in that of the electric regulator, or to measure the light in the direction in which it is most intense. Now experiment has shown that the maximum intensity of an electric focus occurs in a direction making an angle of 50 to 60 degrees with the horizontal plane; thus it is at this angle that its light should be measured.

It may be well to remark that the inequality in the quantities of light emitted in different directions is not peculiar to the electric focus, and that according to M. Allard, an oil lamp, when the measurement is made in a direction inclined 50 degrees below the horizon, gives only one-fifth of the light which it emits in the horizontal plane.* Thus the quantity of light, in this case, as in the other, has a maximum, with this difference, that in the case of the oil flame the maximum is in the horizontal plane, and in the case of the electric focus it is at the surface of a cone of which the generatrix is inclined about 60 degrees below or above the horizontal plane, according as the positive carbon is above or below the other.

Since in workshops and in most industrial applications the lamps and regulators are placed in a somewhat elevated position in relation to the objects to be illuminated, we might in our calculations have taken as the intensity of a machine the maximum it can produce in the most favourable direction. But we have preferred to make direct experiments to determine the mean of the luminous intensitities in every direction, as well above as below the focus. In this manner we shall bring forward real measurements which may be taken as a basis for calculations in practice, and not special determinations in a single direction.

The table No. 1 sums up the results obtained in this first series of experiments.

TABLE I.

SIEMENS' INTENSITIES IN VARIOUS DIRECTIONS (CONTINUOUS CURRENTS).

View from below.		View from above.		
Inclination to the horizon of the luminous ray observed.	Luminous intensity in Carcel burners.	Inclination to the horizon of the luminous ray observed.	Luminous intensity in Carcel burners.	Observations.
0°	225	0°	225	During all these experiments, the velocity of the machine was 750 turns, the motive power absorbed 202 kilogrammètres, the distance between the carbons 3 mm, the length of the cable 160 metres, and the consumption of carbon 7 cm. per hour.
15°	400	15°	144	
30°	822	30°	130	
45°	1175	45°	119	
60°	1135	60°	79	
75°	1051	75°	21	
90°	0	90°	12	

Taking the mean of the intensities measured in 24 directions, 12 to the right and 12 to the left, we found 458 as the number of of Carcel burners. This shows that the light measured horizontally is very nearly one half of the mean light emitted in every direction.

From this it follows that, if we wish to know the luminous intensity of an electric apparatus giving continuous currents, it will suffice to make a photometric determination with the Carcel lamp, the regulator and the photometer being in the same horizontal plane, and to multiply by 2 the observed intensity. The product obtained will be the true mean of the intensities.

If, instead of using a continuous-current machine, we employ one which gives alternating currents, the results are very different. The maximum intensity is observed at 15 degrees below the horizontal plane, and it differs extremely little from the intensity observed horizontally.

The intensities observed horizontally are generally inferior, with a given expenditure of motive power, to those obtained by means of continuous-current machines; we have, however, recorded below an experiment in which the determination was 225 *becs* for 205 kilogrammètres absorbed; that is to say almost exactly what was obtained in the corresponding experiment recorded above. But there is no further similarity between the results obtained with these two sorts of machines, and the inferiority of those with alternating currents is well shown by table No. 2.

TABLE II.

LUMINOUS INTENSITIES IN VARIOUS DIRECTIONS (ALTERNATING CURRENTS).

View from below.		View from above.		
Inclination to the horizon of the luminous ray observed.	Luminous intensity in Carcel burners.	Inclination to the horizon of the luminous ray observed.	Luminous intensity in Carcel burners.	Observations.
0°	225	0°	215	The power employed during the whole period of the experiment was 205 kilogrammètres
15°	230	15°	207	
30°	225	30°	195	
45°	207	45°	180	
60°	180	60°	180	
75°	127	75°	140	
90	0	90°	0	

The mean of 24 observations is 160 Carcel burners. Thus the ratio between the total lights produced by continuous-current and alternating-current machines is 458 to 160. The former produces 3 times as much light as the latter.

Amongst the causes that may influence the quantity of motive power absorbed by a continuous-current machine, we will successively examine those relative to the velocity of the machine, the length of time it works, the distance between the carbons, and the dimensions of the conducting cables.

All the experiments we are about to describe were made with the greatest care in the laboratory of M. Gramme, who was kind enough to aid us with advice, and to supervise the photometric and dynamometric results.

The generator of electricity was of the normal type; it had received some improvements in the details which have recently been worked out by the inventor, and had come from the workshops of MM. Mignon and Rouart. The regulator was according to the Serrin system, and was manufactured by M. Bréguet.

The carbons were 13mm. in diameter, and were manufactured by the Gaudoin process.

The motor was a horizontal gas engine on the Otto system, having a maximum power of five horses. A Giraud gas regulator corrected the variations of pressure which otherwise would have affected the working of the motor.

The Gramme machine was worked directly by the motor, so that we had not to take into account the work absorbed, often irregularly, by intermediate transmission.

The conductivity of the cables was 0 95, that of the agent being 1*.

The velocity of the motor was 160 revolutions per minute. The number of the explosions of gas varied, according to the power employed, from 40 to 80 per minute.

The estimation of mechanical work could at any moment be made, very approximately, by counting the explosions; but, in order to avoid all causes of error, we applied a Prony brake to the fly-wheel of the motor after each determination of the luminous intensities. By adopting this course, we are certain of the accuracy of the results in relation to the motive power.

The determination of the luminous intensities was made by means of a Foucault photometer. Three persons successively examined the photometer, and regulated the position of the oil lamp; and we entered, not the mean of the observations, but only that which was the least favourable to the electric light.

(TO BE CONTINUED).

* Memoir on the intensity and the range of lighthouse illumination, 1878, p. 210.

* In the original there appears here to be a misprint; the word translated "agent" being printed as *argent*. What is termed "conductivity" should doubtless be *resistance*, the unit of measurement being the Ohm.—ED. E.

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WHO'S FIRST?

We are in possession of so many good things, and yet care so little how we came by them, that our anxiety to father what we ourselves have made is as curious as it certainly is unavailing. If inventors have always taken as much pains to transmit their names to posterity as do those of our own day, their efforts have been singularly abortive. That Walter Raleigh invented smoking is about as true as that Jablochkoff invented Electric Lighting, and as false as that spring-side boots came up of their own accord. Nobody asks who discovered gas, and nobody cares who invented corkscrews. True there is a monument here and there to the memory of a great inventor; but it is oftener to the greatness of the man than to what he is supposed to have discovered or invented. Mankind has in fact followed a true instinct in honouring him chiefly who has grasped the significance of a new fact, and elaborated from it potent results, rather than him—often quite another person—who first noticed it.

With these obvious facts before us, it is remarkable that so much stress is laid upon mere priority of discovery. This is an inventing era, and it is an era of patents. For the purposes of the market priority is a think to fight about. Victory on a patent means money; but it means nothing more. Distinction and honour are not to be had in that way. Posterity will act just as it sees fit towards our reputations without reference to the Patent Office; and we cannot win an imperishable name by success in a speedily forgotten lawsuit. Nor is contemporary opinion much influenced by verdicts of any sort, whether legal or scientific. It has its idols and its aversions; which, for the present, are unassailable. That men should wrangle about their right to priority in the field of discovery is therefore a thing to be wondered at, and not at all to be proud of. Yet vexatious disputes of this kind are continually recurring. Bad blood is roused on all sides; and, what is more lamentable, scientific assemblies treat such matters in all seriousness as if they were of real consequence. The medical profession is perhaps the only one enjoying something like immunity from these contests. It approaches most nearly to an ideal corporation of learning, where everything is given and accepted for the common good, in which all alike participate; and where eminence is achieved by inherent worth, and rarely by smartness in running races for honours.

The professions most frequently disturbed just now by conflicting personal claims are those directly or indirectly concerned with electricity. They are due probably to the immediate practical and mercantile ends to which electrical discoveries can be turned to account. This is only a reason, however; it is hardly an excuse; for the less obtrusive sciences have—sometimes in a higher and more enduring sense—their practical utility also. What is to be deprecated therefore is the mixing up of two different and often antagonistic considerations. Question of money should be frankly avowed as such; question of honour as something quite distinct,—not necessarily personal; always to some extent mutual. So far from this being fully recognised we have grave professors solemnly debating whether Dr. this or Professor that was first by a few minutes to lodge a paper in their hands. Such too is the artificial value attached to priority of this particular kind that Mr. So-and-So's merits are absolutely denied altogether if he neglect the accustomed precautions. Not long ago one of the foremost men in the scientific world favoured a public audience with an elaborate justification of this method. "By no other means," said he, "can we adjudicate on such matters in the absence of 'sealed packets.'" Perhaps not; but why adjudicate at all? and, especially, why *we?* The one merit of the "sealed packet" is, perhaps, that it can be cancelled if repented of. But what is there to be said for a system which encourages the weak-minded Smith and the shifty Brown to chase down Albemarle-street for priority of discovery? The priority, in all likelihood, is not theirs; but rightfully belongs to a modester man than either. Then there comes a wrangle as insincere as it is unseemly,—insincere because all the parties concerned are well aware that they are quarrelling over what is virtually common property by a process of evolution and development. Instances of unexpected and independent discovery are rare, and are besides so unique that no question about priority can possibly arise. It comes to this, then, that individual merit, if undeniable, requires no

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artificial awards, and if questionable will not be assisted by them,—posterity, in any case, being the final arbiter.

It would be unfair, however, not to notice one element of discord which has certainly a justification in fact. There are pretenders in science, as in every other calling; but when the science happens to be profitable as well as popular its pretenders develop into cormorants. They appropriate all the inventions; or, failing that, they extinguish the inventors. It becomes excusable, and even commendable, for men of real worth to peremptorily assert themselves in these circumstances. But in truth it is a duty devolving more upon the community than upon the individual. This is perhaps the one legitimate judicial function of the Societies we have referred to; yet nowhere do we see them attempting to exercise it. On the contrary what they do exercise is a direct temptation to pretenders, and a discouragement to men of solid parts.

One practical suggestion we would make in conclusion; it is that inventors and discoverers should be less reticent about the history of their productions. "I have discovered this," and "I have invented that," are statements open to contradiction, or at least to qualification. But "I was led to investigate this by such-and-such; I then tried that; and now I have found out *this*" carries veracity on the face of it. An ingenuous and modest story told in that way has an intrinsic value for all times; whilst the more ambitious self-asserting style will pay the penalty of vanity some day—though not perhaps in its own day.

In one province of Electrical discovery any serious dispute ought now to be almost impossible. The publication of Colonel Bolton's paper in the Journal of the Society of Telegraph Engineers will protect Electric Lighting from inflictions of that kind in future. If any pretender should arise, a reference to those carefully compiled Historical Notes will dispose of him at once; and if only we could induce the Editors and Correspondents of Daily papers to read Colonel Bolton's revelations, our satisfaction would be complete. But there are other items of discovery, especially in the field of practical telegraphy, which are subjects of contention from time to time, and which we think might profit a good deal by what we have been saying. A little candour on all sides, a frank acknowledgment of indebtedness, a generous reference to the real sources of inspiration, would bring about a general peace, and add greatly to the dignity of the profession.

THE INTERNATIONAL TELEGRAPH CONGRESS AT THE LONDON DOCKS.

On Saturday, pursuant to invitations from the chairman and directors of the East and West India Docks Company, a large party of ladies and gentlemen, including the Delegates to the International Telegraph Congress, members of the Joint Reception Committee of the Post Office and of the Telegraph Companies, and others specially invited, left Blackfriars in the Alexandra saloon steamer on a visit of inspection to the Docks. The visit had been originally arranged to come off on the previous Saturday, the 5th inst., when the tide would have permitted the steamer to enter the Docks; but this not being the case last Saturday the party landed at the pier, and walked to the South Dock, where they first visited the great wool warehouses, in which 100,000 bales of wool can be stored, and as many as 15,000 bales can be placed on show at the same time. During the year 1878, 100,000 bales of wool were sold in these warehouses. From the wool stores the visitors were taken to the top of one of the high warehouses on the south side of the dock, and from this standpoint they had a general view of the whole of the docks. Close beneath them lay the south dock, nearly half a mile in length and 450 in breadth, occupying 26¾ acres; over the sheds which covered the quay on its northern side, appeared the West India export dock, of nearly the same length, and 400 feet in breadth, being 24 acres of water. Beyond this again, looking over the rum vaults and mahogany sheds, could be seen a portion of the 30 acres of water in the West India import dock, 2,600 feet in length and 500 in breadth. To the west lay Limehouse basin, the western entrance to the two larger docks, as well as the western entrance to the south dock, and to the east were the Blackwall basin and the West India Dock basin, connected by the Junction Dock, these forming the entrances from Blackwall reach. Further off, to the north-east, were to be seen the forests of masts rising from the two East India Docks and their dock basin. The various ships in the docks were "dressed" in honour of the visit, and the scene was such as is little likely to fade from the memory. The company, which had been told off into sections, each under competent guidance, were taken over the Warwick Castle, one of Messrs. Donald Currie and Co.'s line of mail steamers which run to the Cape in twenty-one days. After inspecting this fine ship, the company were conducted to one of the floors of the wool warehouse, where they sat down to luncheon, numbering nearly 200, Sir William Baynes, Chairman of the Company, presiding, and the vice-chair being occupied by Mr. Baily, Superintendent of the West India Docks. Among the company were General de Lüders, M. and Madame de Rego, M. Neilson, Dr. Siemens, Lady Baynes, Signor d'Amico, Madame de St. Martial, Count Von Wimpfen, M. Kara, M. Yoskikarva, M. Nakano, M. Hirayama, M. Le Camus, Mr. Ivan Berner, Sir G. W. Elliott, Bart., M.P.; Sir James Anderson, Mr. J. Pender, M.P.; Mr. Otway, M.P.; Mr. Donald Currie and Miss Donald Currie, Herr Magalle, Mr. and Mrs. Hankey, Mr. Preece, Mr. David Powell, Deputy Chairman of the Company; Colonel du Plat Taylor, Secretary; and Captain Marrable, Master of the West India Docks.

When luncheon had concluded the bugle sounded, and the CHAIRMAN rising said:—

LADIES AND GENTLEMEN: We have yet much to see, and therefore I have no desire to detain you long. I will only propose one toast. We are honoured to-day by the presence of a number of gentlemen deputed to attend a congress in London to further the international application of one of the greatest discoveries of the age—Telegraphy—not the least happy consequence of which discovery has been the bringing together in common brotherhood and for friendly intercourse and discussion a meeting of eminent representatives from nearly every civilised state. The results of the interchange of the ideas and experience of these eminent practical men cannot fail to be productive of benefit and much advantage to the world at large; and, feeling this, we all hail the conference with satisfaction, and welcome its members individually and collectively, not only as our guests to-day, but as the harbingers of peace between the nations essential to commerce, and to the welfare of peoples. I propose the toast: "Health and Success to our honoured guests, the Members of the Telegraphic Conference" [cheers].

The toast was drunk with enthusiasm.

General DE LÜDERS, who spoke in French, said: Ladies and Gentlemen: I feel it an honour to be called upon to discharge the duty of replying to the speech of your estimable chairman, in the name of the Conference now sitting in London upon the International development of telegraphy. During our stay in England, we have had opportunities of seeing many remarkable things, but to-day we have seen what is altogether exceptional and more remarkable than anything in England which we have hitherto seen. The sight which lay before us as we mounted on the balcony to which we have been conducted showed us that the country in which we stand is the Queen of the Seas [cheers]. We saw beneath us vessels from all the countries of the earth, which had brought the products of the different parts of the world to London, laying their tribute at the feet of the Queen of the Sea [cheers], and thus proving that all the countries of the world are tributaries to England. I will not enter into any description of these docks, the details of which are so well explained in the paper that has been given us. But there was one thing which struck me exceedingly, namely, that this has not been the work of the Government, but of a private company. Such enterprises as these, and so admirably conducted, are sufficient to inspire faith in the enterprising character of the English, and this is thoroughly recognised by all the nations of the earth. I have a toast to propose, and it is to the managers of this great enterprise, "To the Chairman and Directors of the East and West India Dock Company" [cheers].

The toast was drunk, standing, amid loud cheers.

The CHAIRMAN, in a neat speech delivered in French, thanked General De Lüders for the manner in which he had proposed the toast, and the company for their cordial reception of it. He wished he could fully express the great pleasure which it had afforded to himself and his brother directors to have the members of the Conference as their guest, and he hoped they would have agreeable recollections of their visit to the docks, both of

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what they had already seen and what they were about to see before leaving.

The company then rose, and having again collected in their divisions under their respective leaders, paid a visit of inspection to the John Elder, a ship belonging to the Orient line of mail packets between London and Australia. After this they embarked in the tugs of the company, and proceeded through the Junction Dock to the West Indian Import Dock, where, having noted on the way the railway bridge and the Dock Company's railway and sidings, a visit was paid to the rum vaults, in which some 40,000 puncheons of rum are stored, and in which the visitors were shown the process of mixing the rum from several puncheons in large vats in which the rum is stirred up by machinery until effectually blended together. The next place was the coffee warehouse, where the coffee is mixed and repacked in its casks. An ingenious machine, invented by one of the Company's staff, is here in use for beating the casks, so as to allow of their again containing the quantity originally imported. Next the visitors proceeded to the north quay of the import dock and saw the storage, sampling, &c., of sugar, here they had further the advantage of seeing a couple of bags of sugar drop from the slings at a considerable height and burst in falling on the pavement beneath, an accident such as the officials and directors present could not remember they had ever before seen. Having further seen the tea sheds, the engine house, the museum, the kitchen, &c., the company re-embarked in the steamer and returned to town, much gratified and instructed by their visit to the docks.

CORRESPONDENCE.

ELECTRO-DEPOSITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue is a note on "Electro-Deposition of Metals," in which you refer to an arrangement for regulating the strength of current in the depositing trough by a resistance capable of being varied at will. I just wish to point out that there is no novelty in this; experienced workers in this business have used a resistance wire of copper and German silver for this purpose for some years. The resistance is varied by a circular series of contacts, which are joined to different portions of the wire, and, by means of a lever passing over them, any length of the wire can be included in the circuit.

I am surprised that no mention is made of this in any work on Electro-Deposition which I have met with. In practice I believe it is found best to attach the coil near the troughs, so that the operator can watch the deposition and adjust the current necessary for the work in hand; thus the same battery or machine may work several depositing troughs when, perhaps, different solutions requiring different currents are in use, or even the amount of work going on in one tank may necessitate special adjustment. Thus it is even possible, in a tank holding several hundred gallons of solution, to electroplate the smallest article, such as a lady's thimble, or a number of articles having an aggregate surface of several feet, by simply using a variable resistance.

Yours, &c., THOMAS T. P. BRUCE WARREN.

Silvertown, Essex, July 12, 1879.

ANSWERS TO QUERIES.

B.—It may be advisable to withdraw the zincs, as these may become corroded near the surface of the fluid; but the porous pots, when once saturated with the solution, should never be allowed to become dry.

A. STUDENT.—Amalgamation prevents the consumption of zinc by the action of minute local circuits formed by the metal and the impurities on its surface. It does this by coating the surface with a homogeneous amalgam, which is positive to zinc.

THE DAILY PAPERS AND MR. EDISON.

The Times Correspondent sends the following information relating to the work of Mr. Edison:—

Mr. Thomas A. Edison, of Menlo Park, New Jersey, yesterday (June 30) gave a private exhibition of his new electro-chemical telephone, of which during the last few months remarkable results have been predicted. About 30 or 40 journalists and friends of the inventor went over to his laboratory, where the exhibition was given by Mr. Edward H. Johnson, Edison's chief assistant. He was found surrounded by the queer-looking machines, and explained that only 50 of them had yet been finished, and that he would leave with these 50 for London on board the Wisconsin, which sails to-day, and carries this letter. Mr. Johnson is commissioned by Mr. Edison to establish in London a telephonic exchange, with a switch-board in the centre of the City, and wires radiating thence towards the suburbs; and the prime object of the exhibition yesterday was to demonstrate the immense superiority of Edison's new telephone to all others in use.

Mr. Johnson first took in his hand the receiver of the Bell telephone (the one now best known), and showed its capabilities. As is well understood, the voice transmitted by this telephone can be heard only by putting the receiver to the ear. He then exhibited the Bell telephone with the Edison transmitter, a carbon button, but the voice was still very faint, the articulation being audible only when assisted by the flaring tunnel used in the phonograph. Then he turned to one of the odd-looking contrivances before referred to, which was fastened to the wall, and which looked like a coffee mill with a glass front, and giving the signal to the sender, who was in a distant part of the grounds, he turned a little crank revolving in the edge of the coffee mill, and it shouted in a voice that startled the listeners, "Halloo! How are you? How do you get this?" The voice was so loud and strong that it might have been heard and distinctly understood 50 feet distant; indeed, some members of the party went into the next room, and still heard it saying,

Now is the winter of our discontent
Made glorious summer by this sun of York;

and when the talker turned from familiar verses and read the latest news from a morning paper, and, finally, read a page of travels from an unknown book, every word was distinctly understood. I ought, perhaps, to qualify this by saying that some whose ears are not familiar with the peculiar, half-muffled, half-metallic voice of the telophone and phonograph missed some words, and that some acquaintance with the instrument seems to be essential to a complete understanding of all its speech.

It is doubtless already known to your readers that this telephone contains no magnet (which has hitherto been regarded as essential), and that Mr. Edison has substituted for the magnet a carbon-button transmitter at the end where the speaker stands, and a small revolving cylinder of chalk at the end where the hearer awaits the message. This spool of chalk is turned by the crank before mentioned, and its mysterious virtue seems to reside in the caustic soda with which the spool has been thoroughly saturated, and which, Edison explains, must crystallize and polarize before becoming effective. On this spool rests a steel tongue, about as large as the wooden toothpick of commerce, free at one end, and at the other fastened in the centre of a disc of mica, which it causes to give vocal vibrations like the mica disc in the phonograph.

The visitors experimented with the new phonograph in every conceivable way, and the conclusion shared by all was that it is so much more powerful than any other phonograph as to lift it almost above rivalry. Experiment also showed that the voice is really magnified in transmission, and delivered in a louder tone than that employed by the speaker.

The visitors were then marched the length of the great barn-like structure, where they found Edison himself, standing, without hat or coat, by the side of his new generator, built for the electric light. This concern is about 5ft. high, and looks like two stove-pipes standing on end, with a great piece of iron across their tops to hold them down, and another great piece of iron underneath to hold them up. The stove-pipes are closely wound with fine copper wire, and a shaft revolves like lightning through the iron beneath.

"Will it do the work you have been anticipating?" he was asked. "Yes," he replied, confidently; "I can, with that generator, furnish six lights to one horse-power, and those lights cost me only one-third as much as the first cost to the manufacturer of three similar gas jets. I claim that this solves the problem."

He then exhibited the standard with the spiral of platinum at the top, which, for want of a better name, he calls a lamp, and explained the simple and ingenious process of subdividing the current by a lever operated by the heat to which it is subjected.

It should be mentioned here that the one obstacle which Edison meets with at present to the complete practical success of the electric light is the high price of platinum for his incandescent coil. No other metal will answer; so Edison has sent a dozen explorers to California, Mexico, and South America, to ransack the gulches, and find, if possible, some large and constant supply of plantinum.

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THE RISE AND PROGRESS OF SUBMARINE TELEGRAPHY.*

(CONTINUED FROM PAGE 77.)

Such a gigantic achievement as the successful laying of the 1866, and completion of the 1865 Atlantic cables, naturally called for a public recognition of the services rendered by those in charge, and Her Majesty was graciously pleased to confer the honour of a baronetcy upon Sir Curtis M. Lampson, Vice-Chairman of the Atlantic Telegraph Company, and Sir Daniel Gooch, Vice-Chairman of the Telegraph Construction and Maintenance Company. The following gentlemen received the honour of knighthood:—Sir Richard Glass, Sir William Thomson, Sir Samuel Canning, and Sir James Anderson. Honours were also offered to the chairman, the Right Hon. J. Stuart-Wortley, and to Captain Hamilton, but in both instances they were respectfully declined.

The cables were opened to the public at the costly experimental tariff of £20 per message of twenty words. This charge was gradually reduced, until at one time, owing to competition, it fell as low as one shilling per word.

From this date cables of various lengths began to be laid in various parts of the world, with a marked success over that of previous years. We shall only enumerate a few of these enterprises, and must refer you for further information to the table drawn up by the Eastern Company in 1879, which shows the lengths and positions of the various cables at present in working order.

Following up the history of Atlantic telegraphy, we find that in 1869 a cable was laid from Brest, in France, to St. Pierre Island, 2,584 knots in length, or 732 knots longer than the 1866 Atlantic line. In 1873 a cable was laid from Ireland to Newfoundland, 1,877 knots in length; and in 1874 two cables were laid, the one by the Telegraph Construction and Maintenance Company, for the Anglo-American Telegraph Company, 1,837 knots in length, from their station at Valentia to that at Newfoundland; and the other by Siemens Brothers, for the Direct United States Cable Company, from Ballinskellings Bay, Ireland, to Torbay, Nova Scotia, 2,422 knots in length.

Altogether seven lines, representing about 18,000 knots of cable, have been laid across the North Atlantic Ocean, of which at present four are in working order, namely, the 1869, 1873, and two 1874 cables.

Several attempts since 1873 have been made to repair the 1858, 1865, and 1866 cables, but they all ultimately resulted in failure in the *very deep water*.

The experience gained in these repairs has no doubt been very valuable, and tends to prove that, where practicable, greater depths of water than 1,000 fathoms should be avoided; for although there was no great difficulty in hooking and elevating the cables by means of improved appliances when working in a depth exceeding 1,800 fathoms, yet in almost every instance the cable parted before it reached the bows. Portions of it were found in perfect condition, but with one exception they were unable to find a piece of sufficient length that would bear raising to the surface.

1870 was a great year for cable enterprise, for in it we find that England was brought into direct communication with three of her most important fortresses, viz.:—*Gibraltar* and *Malta*, *viâ* Porthcurnow and Lisbon, and *Aden*, *viâ* Alexandria and Suez; the line being continued to Bombay. France was also connected to this main line with the East by a cable from Marseilles to Malta, *viâ* Bona. The whole of these cables were made and laid by the Telegraph Construction Company, and now form part of the extensive and important system belonging to the Eastern Telegraph Company, under the management of Mr. Pender and Sir James Anderson.

In the same year Bombay was connected to Madras by a direct land line across India, worked by the Government, and the Eastern Extension Company connected the latter place by cable with Penang, Singapore, and Batavia; while, in 1871, they extended their system to Hong Kong on the one side and Australia on the other. The Great Northern Telegraph Company laid a line from Hong Kong to Amoy, Shanghai, Negasaki, and Vladivostock.

In 1871, therefore, was constructed the long stretch of almost unintermittent submarine communication between England and India, China, Australia, and Japan, as well as to Eastern Russia. This had a great effect upon the commercial world, for it placed all on an equal footing, and afforded an opportunity to the great and small merchant of knowing at the same time the state of foreign markets, and thus annihilated to a certain extent the heavy speculations of wealthy and influential houses.

In 1873 and 1874 the Brazilian Submarine Telegraph Company connected Lisbon with South America, *via* Madeira, St. Vincent, and Pernambuco, with 3,667 knots of cable, made by the Telegraph Construction and Maintenance Company, and the Western and Brazilian Company joined all the more important coast towns of Brazil thereto, by connecting Para, Pernambuco, Bahia, Rio de Janeiro, Santos, Santa-Catharina, and Rio Grande-do-Sul, with 3,427 knots of cable, of which that between Para and Rio de Janeiro (2,517 knots) were made and laid by Hooper and Company, and the remainder by Siemens. We shall have something to say about Hooper's core when we come to consider the comparative merits of india rubber and its compounds with gutta percha, as an insulating material.

In 1875 the cable was extended from Rio Grande-do-Sul southward, and joined another short cable at Maldonado, which had been laid about a year and half previously to Monte Video, &c. In the same year the West Coast of America Telegraph Company joined up some of the more important towns on the West Coast of South America, including Valparaiso and Chorillos, by cable, and communication with the East coast was effected by land lines and a snow cable, or a cable laid across the snow-peaked Cordilleras of Andes. This placed England for the first time in telegraphic communication with the whole South American Continent, *viâ* Lisbon, Pernambuco, Monte Video, Buenos Ayres, Valparaiso, &c. She was also in communication with her West India possessions *viâ* New York, owing to the failure of the Central American cables from Para to Demerara, &c. These West Indian islands had been joined together in 1870 and 1871 by Sir Charles Bright for the West India and Panama Companies.

The years 1876 and 1877 were busy ones for makers of submarine cables, for the Eastern Company employed the Telegraph Construction and Maintenance Company to duplicate their system between Marseilles and India, thus giving to the former company a double string to their bow, and a certainty of being able at all times to keep up telegraphic communication with the East. Besides this, duplex working on cables was proved practicable, and had been successfully applied throughout the Eastern Company's system between Marseilles and Malta, Suez and Bombay.

The year 1878 was uneventful compared with those preceding, although it may be mentioned that the Eastern Telegraph Company extended their Levant system up the Dardanelles to Constantinople, and from Tenedos to Salonica, as well as joining Cyprus to their main line at Alexandria, for the convenience of the English Government.

When we consider the number of places which are connected together, the number of persons employed in the different services (necessary to make, keep in order, and work the various submarine systems), and the large amount of capital invested, representing some twenty-five millions of money, 65,000 miles of cable, and finally, knowing that nine-tenths of all this emanated from the banks of the Thames, one cannot but admit that submarine telegraphy owes its existence and continuance to English pluck, English perseverance, and English money, and must be pre-eminently considered an English enterprise.

In my next lecture I hope to give you a description of the "necessary instrumental arrangements for submarine telegraph offices."

* Lectures on Submarine Telegraphy, delivered at the Malta Station to the staff of the Eastern Telegraph Company, by A. Jamieson, C.E.

EASTERN TELEGRAPH COMPANY (LIMITED).

The fourteenth ordinary general meeting of this Company was held on Monday, the 14th July, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. John Pender, M.P., the Chairman of the Company.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting and the minutes of the last meeting;

The CHAIRMAN, after signing the minutes as correct, said: Well, gentlemen, before moving the adoption of the report, I shall, as usual, give you a few of the figures of interest as to our progress since I last had the pleasure of addressing you. The net revenue of the Company for the six months ending the 31st March, 1879, amounts to £235,077 14s. 5d. as against in the corresponding half year of 1878 £238,114 15s. 11d., or a decrease of £3,037 1s. 6d. This arises, to some extent, from the depression of trade. The gross receipts are about stationary, but the deductions from messages for loss on remittances home are much greater in the present than in the corresponding half year, in consequence of the very low state of the exchanges. When I tell you that the loss by exchange has been £7,000, that will give you some idea of the depreciation of Indian exchange at the present time. It is satisfactory, however, to state that since the 1st of January we have obtained more favourable terms from the Indian Government for the payment of balances due to the Company. I may also mention that the three months' traffic to the end of June shows an increase of £15,874 [hear, hear]. I am hopeful from these figures that there is some evidence—or that it is a distinct evidence—of better times beginning in India. The ordinary expenses of the Company amounted to £67,953 3s. 4d. against £58,101 14s. 3d. in the corresponding period of 1878, or an increase of £9,851 9s. 1d. This, however, includes an item of £4,000 which is set aside as a reserve for renewal and special repairs of maintenance ships. The main items which show an increase are as follow—Salaries and wages

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at stations and rents, in the half year now under review, embrace the charges of forty-one stations against twenty-nine in the corresponding half of 1878. Since the termination of the Russian war, however, reductions have been made in the staff to a considerable extent, the effect of which will not be made manifest till the next balance sheet. On the other hand, the expenses of maintenance show a decrease of £1,600, the general expenses in London show a decrease of £76; the working expenses at stations show an increase of £6,905, an explanation of which I have already given. The use of patents shows an increase of £700; the foreign agencies show an increase of £38; the directors' remuneration shows a decrease of £150, or at the rate of £300 per annum. This reduction is owing to the resignation of Sir Charles Wingfield, to which I referred at the last meeting. Depreciation of maintenance ships and London office furniture is £574 against £2,150, or a decrease of £1,576; but in addition to this £574 we have likewise charged revenue with a sum of £4,000 for the year, which is carried to a special reserve, as I have already mentioned. The extraordinary expenses are —repairs to cable, six months to date. The total cost of the repairs was £23,476 18s. 1d., against £26,179 17s. in the half year to March, 1878, or a decrease of £2,693. This sum includes £5,224 for new cable expended in repairs, the balance being the expenses of the repairing ships. The repairing ship, the ss. John Pender, effected repairs to the direct Lisbon cable, which was interrupted on the 31st of December, and afterwards proceeded to repairs in the Levant. The ss. Chiltern was engaged in repairs in the Red Sea section, but was laid up most of the period at Aden and Suez. The ss. Great Northern also effected repairs on the Lisbon cable on her way from Cyprus. The expense of issuing the 5 per cent. debentures was £459. This was principally for stamps on bonds and the cost of printing the bonds themselves. The bad debts only came to £329, as against £602 in the corresponding half, or a decrease of £273. The income-tax shows an increase of £448. The full details of the increases and decreases of each item under Abstracts A and B are as follow, but as they form a great number of items, perhaps you would not wish me to read them all. They amount to this: that the increase under Abstract A is £331, and the decrease is £407, leaving the net decrease £76; and under Abstract B the increase, as I have stated, is £8,765, while the decrease is £1,860, leaving the net increase £6,905. Now, gentlemen, I think these figures show you pretty fairly the working of the business during the last six months. I am glad to say that our cables at the present moment are in fair working order, and that our revenue is showing considerably better than it did at this time last year. With a return of good trade there is no doubt that we shall find also a very considerable increase in our revenue. I have very little to say further in regard to our system. The really important question which I have to bring before you to-day is the question of the cable which is about being laid to South Africa. Now, gentlemen, I intend to bring before you, and to ask your acceptance, of a resolution to-day, in regard to that cable. We intend to establish a distinct company to carry out the Cape cable. But, probably, as that is a distinct business, I think the better way will be to ask you to approve of the report in your hands, and then I shall submit a separate resolution in regard to this Cape cable business, as it may probably lead to some little discussion, and it is well that we should have the views of our shareholders on the subject. I shall ask your approval of the report and of the following resolution:—" That the report and accounts of the Directors submitted to this meeting be and they are hereby received and adopted, that a dividend on the preference shares of the Company to the 30th June, 1879, at the rate of 6 per cent. per annum be paid, less income-tax, and that, in accordance with the Directors' recommendation, a dividend be and is now declared of 2s. 6d. per share, free of income-tax, on all the ordinary shares of the Company, making with previous payments by way of dividend on account, a dividend of 5 per cent. on those shares for the year ending the 31st March, 1879."

The Marquis of TWEEDDALE: I beg, gentlemen, to second the resolution.

The CHAIRMAN: Now, gentlemen, it has been moved by the Chairman, and seconded by the deputy-chairman. If any gentleman has any remark before I put it to the meeting I shall be glad to hear him.

Mr. NEWTON: Mr. Chairman, I wish to ask a question with respect to the accounts. You tell us that there are 41 stations now, as against 29 last year, and that, of course, deals with the question which I wish to ask you. It is with reference to the large increase of salaries and wages abroad. Their increase since a twelvemonth has been at the rate of £12,320 a year, and I think that we are entitled to a little more information as to that large increase in the expenses of the Company in one item alone—of salaries. You also tell us that the loss on exchange is £7,000, and I should like a little information on that—it will, of course, be answered all right—but what do you take the rupee at as an average in order for you to say that you have a loss or gain on the exchange? I don't know whether I am right in going into the question now—not as to the new Company—but as to the increase in the debenture capital of the Company. Have you thought of limiting the extent or the proportion of the debenture capital to the ordinary capital? Those are the only questions. With respect to the large increase in the salaries abroad, I think that we ought to have a little more information; with respect to the increased number of stations, and with reference to the value at which you take the rupee to make your calculation of a loss or gain in the exchanges.

The CHAIRMAN: Is there any other question to be put? Well, then, I may say to Mr. Newton, in the first place, that I think we have shown you that there is an increase in the stations alone of 12 stations, and I think that the gross increase that we show you is £6,000 odd. Then there is ——

Mr. NEWTON: £6,160 in the half year; that means £12,320 per annum.

The CHAIRMAN: Yes; quite true. Well, if you take twelve stations, and take them at an average of £500, you have £6,000 to begin with, and if you take the loss of £7,000 on exchange you have the net amount without any difficulty. As to fluctuations in the exchange it is very difficult for me to give an opinion. The wisest men at the present moment are baffled by this question of silver, and if there is any hon. gentleman who can throw any light on the subject I am sure that it will not only be acceptable to me and the Board generally, but also acceptable to a great many others who are deeply interested in the trade; but I may mention to you that we have not been idle and have not been thoughtless on this particular question, and we have entered into an arrangement now with the Indian Government which will give more favourable terms to the Company as regards the value of the rupee.

Mr. NEWTON: That leads me to another question. Have you some arrangement with the Government that they take any risk of the fluctuations in the price of silver and in the value of the rupee? As I understand it you collect your revenue in Calcutta in rupees. We cannot take any benefit from the Government in that respect; we must take the chance if the exchange is 1s. 6d. And I do not think that we ought to consider that we make a loss on exchange unless you, for convenience in the accounts, take the value, say at 20d., which is 1s. 8d. in our money, but received abroad in the rupee. We certainly must take the risk of it being remitted home, like any merchant, unless the Government is so kind as to give us an increase on the value to that prevailing in the markets abroad. That is what I mean—not that we take any benefit from anyone, but that we take our chance like any merchant.

The CHAIRMAN: I think that if you asked any merchant who sends out goods to Calcutta he will tell you that it is a question of the exchanges where he makes a loss where otherwise he expected a profit. But the Indian Government forms part of our joint purse; and in future we have arranged with the Government that it is to be taken at about 1s. 7½d., and, therefore, any variation below that must be to our detriment; but above it, as it is now, it is in our favour. Now, gentlemen, I think those are the only two questions I have been asked, and I hope that I have answered them satisfactorily.

The resolution for the adoption of the report was then put to the meeting, and carried unanimously.

The CHAIRMAN: Now, gentlemen, the next question that I have to put before you is this question of the Cape cable, and after having made a few remarks in explanation I shall put a resolution to the meeting. The arrangement that we have entered into is explained so far in the statement put before you. It was at one time thought that it would be better that the Eastern Company should take the whole responsibility of this transaction, but on consideration we thought that it was not only better for the Eastern Company, but also probably better for those who might be disposed to invest in this new undertaking, that we should have it as a distinct undertaking. It will be managed entirely by the Eastern Company, and under our control. The amount of the subsidies received from the Imperial Government and the Cape Government will be applied to pay the interest and sinking fund upon the amount of money that is raised. The benefit to the Eastern Company will be this—we shall have the benefit of a moiety of the traffic passing over our lines from the Cape. Now, the object of the Eastern Company in taking up this scheme is that they believe that it will add not only materially to our reserve, but that it will add materially to the security of the Company as a whole. If that company had passed into the hands of any other combination, and they had laid the cable from the Cape to Aden, they must of necessity have done something further. They must have had their line to England, and they must have had their line to India, and, therefore, we should have had to meet a very formidable opposition [hear, hear]. As it is, in the part we take now we have the entire control of the company, and as far as our experience goes our calculation, based on what we have done in other sections which we have added to this system, is that something like £15,000 a year should be added to the Eastern Telegraph Company's revenue as a beginning [applause]. For that we are going to take a certain interest, in the form of shares, in this new company. These shares will give us, I believe, the entire control of the company, and, as it will be worked by us, we think that we place ourselves in a position that it will be impossible for any one to interfere with us, and, consequently, we secure all the benefit arising from this additional telegraphic system. I may mention that this could not have been done by the Eastern Company alone had they not been supported in a very strong—I would say in a very liberal—way by the Telegraph Construction Company [applause]. They are largely, very largely, interested in this Company, and they have shown their belief and their good faith by going on with the cable at the present time, even before the company has been brought before the public. I think that that is an act which entitles them to the very highest consideration and credit, as it is done when the laying of this cable has almost become a national necessity [applause]. We are, as I have said, acting in connection with the Telegraph Construction Company, but we have felt that it would be only fair to our shareholders that we should keep the two concerns as distinct as possible, but, at the same time, show that it was to our interest to support this Company in every possible way, and, to do that, we are obliged to take a certain amount, probably a couple of hundred thousand pounds, in this new company. But when I tell you that, as to that couple of hundred thousand pounds, the interest is secured on it, that we are paid, and that it brings into our revenue account from the working of the system something like £15,000 a year to begin with, you will see that we are perfectly secured whichever way we look at it. With these remarks I will read the resolution. Mr. Burt (the Solicitor) very properly suggests that we had better first read the agreement that we have made with the Imperial Government, and then I shall read the resolution.

Mr. BURT: I have here a copy of all the agreements and arrangements come to; but they are voluminous, and would take a very long time to read. The agreement between Her Majesty's Government, the Eastern Telegraph Company, and the Telegraph Construction Company, is to the following effect. I propose to give you the substance of the various clauses, but if any one desires that the agreement should be read in full I should be very happy to do so [no, no]. The Agreement with Her Majesty's Treasury provides that:—

"The companies shall, by means of moneys to be provided by them, establish, with proper stations, &c., a line of telegraph cables between Durban and Aden, touching at Delagoa Bay, Mozambique, and Zanzibar, and thenceforth effectually work them.

"The cables are to be capable of transmitting 14 words a minute.

"The line between Durban and Zanzibar (save in case of *force majeure*) is to be completed by the 31st July, and between Zanzibar and Aden by the 31st December next.

"A suitable steamship is to be provided for repairing the line.

"Government messages are to be transmitted at half rates.

"The rates for the public are to be:—

Between Durban and Aden 5s. a word.
,, Zanzibar and Aden 4s. a word.
,, Aden and London 3s. 9d. a word.

"The Treasury may nominate an official director on the boards of the companies owning and working the line.

"The Treasury is to pay, from the completion of the line between Durban

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and Zanzibar, for 20 years an annual subsidy of £17,500, and a similar subsidy in respect of the line between Zanzibar and Aden.

"The subsidies are to be payable quarterly, and to be independent of any subsidies granted by the Colonial or other Governments.

"The payment of the subsidies is conditional upon the line being in good working order, with a proviso that, in respect of the line between Durban and Zanzibar 3 months, and between Zanzibar and Aden 6 months should be allowed for repairs before the subsidy ceases to be payable; and the Treasury may extend the periods if it is proved to their satisfaction to be necessary and proper.

"The subsidies recommence when the lines are restored to good working order."

The agreement is dated May 9, 1879, and has been signed by two of the Commissioners of Her Majesty's Treasury. There is a provision that the agreement is not to be binding until it shall have been approved by a vote of the House of Commons. I have in my hand copies of the Acts passed by the Parliaments of the Cape of Good Hope and of Natal, but I do not think it will be necessary for me to read them to you. The arrangements with the Cape of Good Hope are contained in letters written by the Eastern Company, and the Crown agents of the colony, and their effect shortly is that an engagement is taken to grant to the Company by the Cape Colony a subsidy of £15,000 a year, payable quarterly for twenty years. The rate of charges for Government messages to be half those charged on the messages of the general public. Then, with regard to Natal, a corresponding engagements is made, to the effect that the Natal Government shall pay a subsidy of £5,000 a year, analogous terms being specified as in the case of the Home Government. There was a discussion as to the amount of the subsidy, which has been decided at length at £15,000 a year by the Cape Government, and £5,000 a year by Natal, and the Crown agents consent to the terminus of the cable being at Natal, Durban, and not in the Cape Colony. A letter which was written on the 31st March by Sir James Anderson to Mr. Sargeaunt, the Crown agent of the colony, sets forth shortly what the payments are, that of the British Government being £35,000, the Cape Government £15,000, Natal £5,000, and Portugal £5,000 for 20 years, payable quarterly. Then I have a copy of the translation of the contract made on the 21st May, 1877, between the Portuguese Government and the Company. It sets out that the Portuguese Government shall pay £5,000 a year, as stated in the report. Then I have a copy of a letter from the Sultan of Zanzibar to Dr. Kirk, Her Majesty's consul there. It says:—

"Will you be good enough to convey to H.M. Government the gratification with which I have received intelligence that the cable will now shortly be laid that will connect the British possessions in South Africa with Europe, and that it has been decided to make Zanzibar one of the principal stations on the line.

"On a former occasion I conveyed through you to Mr. Pender, the agent of the Eastern Telegraph Company, an assurance that whoever carried out this great undertaking, so beneficial to my dominions, might rely on my full assistance and support. I then explained in what way this might be rendered, and I regretted that it was not in my power to give pecuniary assistance, which, as you are aware, is not within my power. As now there is an immediate prospect that the cable will be laid, I take this opportunity of renewing my promise of assistance, by granting to the Company chosen by the British Government to carry out the scheme the sole and exclusive right, for a term of fifty years, of landing ocean telegraph cables from foreign countries to places in our dominions."

That is dated May 1, 1879, and signed by the Sultan of Zanzibar [applause].

The Chairman: Now, gentlemen, you have heard these agreements read, and if there is any gentleman who wishes to make any remark with the view of eliciting any further information, I shall only be too glad to give it. Probably, before any remarks are made, we had better read the resolution we propose, and then you will know exactly what we ask you to agree to.

Mr. Burt: The Chairman will propose this resolution—"Resolved, that the several provisional agreements referred to in the Directors' report and submitted to this meeting with the Lords Commissioners of Her Majesty's Treasury, the Colonial Governments of the Cape of Good Hope and Natal, the Portuguese Government, and the Sultan of Zanzibar, with respect to a line of submarine telegraph between this Company's station at Aden and Natal, and the arrangements mentioned in the report as to the making, laying, and working of the cables, be and the same are hereby approved and adopted so far as the same relate to the matters and things to be done by this Company, and that the board of Directors be and they are hereby authorised on behalf of this Company to complete and carry into effect the said agreements and arrangements with or without any modifications or alterations from time to time required or approved by the Board; and also to make and carry into effect any other agreements and arrangements with reference to the said cables which the Board may think desirable; and also to subscribe for and accept on behalf of the Company shares and debentures of the proposed Eastern and South African Telegraph Company; and to raise, by the issue of debentures of this Company or otherwise, such monies as may be required for those purposes or any of them, and apply the same accordingly as the Board shall from time to time deem expedient."

The Chairman: Gentlemen, you have heard the resolution, which I beg to propose.

Sir James Anderson: I second it.

The Chairman: It has been moved by your Chairman and seconded by Sir James Anderson. Is any gentleman prepared to make any remarks? If not, I shall put the resolution to the meeting.

Mr. Newton: Mr. Chairman, I wish to make a few remarks, and I am exceedingly sorry that no one else rises. I cannot but express my amazement that no one rises to speak on a question involving an expenditure of £1,000,000, a large portion of which will come from gentlemen holding ordinary capital. I rise as a holder of debentures. Nearly all I possess—nearly every penny I possess—is in telegraphy. I take a considerable interest in this increased expenditure of the Eastern Telegraph Company. I cannot say that I disapprove of the Eastern Telegraph Company taking a considerable interest in the extension of telegraphy to the Cape, as I should have taken just the same interest if the Brazilian Submarine Company had done. It seems to me that any addition to the link of telegraphy improves the property of telegraph shareholders. I want—I have no doubt that you will consider the questions perfectly satisfactory, or most of them—I should like to ask whence come the funds of the Eastern Company which will be put into the ordinary capital of this Cape Company? and also, sir, if there is a limit to the extent of the interest that you will take in the ordinary capital under any circumstances whatever? and also, sir, what extent of debenture capital you intend to take? I should like to know that. If you think it unadvisable to give that information I do not wish for a reply; but still, if there is no reason to the contrary, I think that we should know the amount of ordinary capital in which the ordinary shares of this Company will be. I should also like to know—it is a very important question—will the Telegraph Construction Company take a corresponding interest in this new enterprise with the interest which the Eastern Telegraph Company will take? because, if they do, I shall have still greater confidence in the property. Unless the Telegraph Construction Company has a large interest in the ordinary capital of the new company I shall have very little faith in it. I think, sir, that you should be joint partners as to that ordinary capital. If they are largely interested in it you may depend on it it will be a magnificent cable [laughter]. I would trust not even the Telegraph Construction Company—if they are not largely interested in it—in its ultimate success; for, sir, I believe that you have made a bad bargain with the Government. I am convinced that you might have made a better bargain. I think, sir, that you have been caught napping or you would have got such a bargain from the Cape Government and the British Government that would have made this Company one of the most splendid investments for Englishmen. See what the British Government has done for enterprises ten times more solid. Look what they gave the gas companies—10 per cent., through which they can place their capital at a price which will yield only 4½ per cent. to the investor. What, too, have they done for the water companies? and all Englishmen are imposed on by both the gas and water companies. What has the British Government done in India? guaranteed 5 per cent. to the ordinary investor in the great railway companies of India. And then, what have they done for us here? Nothing by comparison with what they ought to have done. Three or fours years ago I remember that the British Government [I don't speak as a political partisan]—what did they do? Why, they played with the concern, which has since gone to "smithereens," and they said, "We will let you make the cable." And what is the consequence—that the cable was never made at all, because they did not go to a good company—they did not go, for instance, to the Telegraph Construction Company—they went to the Houndsditch of telegraph manufacturers. The consequence was that they did not have a telegraph at all. And what is the result to Englishmen? Millions of money thrown away for ever. The Zulu war would never have happened if the English Government had had a due sense of what they owe to Englishmen and English enterprise [hear, hear]. They have acted in the meanest possible manner, and they have now driven a bargain which is a disgrace, taking into consideration the risk that the new company will take. I believe that the coast on which this cable is to be laid is the least surveyed portion of the universe. I think, under such circumstances, that we should have had more than this twenty years' subsidy. If that does not show the meanness of the British Government what does? I think that we should certainly have got a good deal better bargain than you have, and especially if the Eastern Telegraph Company is going to be interested to any very great extent. I am sorry to say that I do not think that you have made as good a bargain as you might if you had stood out a little longer. I think the "bogey" you hold up is not yet. You could have stood out a long while yet, and the British Government would have given you better terms. I cannot but express my surprise that you have not obtained better terms; and I must say, seeing—I am now going to refer to the old question—seeing the "tremendous" influence of our Directors, I am amazed that, as to that part of which so much is made, the influence of the Directors with the Government has not produced us a better bargain; and it would seem that the influence is not worth so much, seeing the results of this new undertaking, and the sooner you get on your Board two or three more gentlemen of consummate mercantile capacity [hear, hear], the better will it be, not only for you, sir, and your Company, but for every member of telegraph property. I am positive of that, I am so convinced of it, that I thall always hold that opinion so long as I am present at your meetings, and I shall be always, for I believe in telegraph property, and my money will remain in it. The one question I asked before is, "What proportion is the debenture capital to be its limit to the ordinary capital? We continue to increase it. Any one who has the figures before him since the commencement can see the gradual increase of preference capital. I am very pleased to see that it stands at a very magnificent price in comparison. But the debenture capital is continually increasing, while the ordinary capital remains at the sum it was. Well, sir, I think that the ordinary capital of this Company should bear some proportion to the debenture capital and the preference capital, and I wish to know if you have ever thought of placing some limit on it. With respect to the question, I think that you ought to alter your articles of association to a point that you could not increase it without the usual meeting of shareholders to sanction it. That is all that I have to say [hear, hear].

The Chairman: Well now, gentlemen, you have heard Mr. Newton's views explained at full length, and as I had something to do with the making of the bargain I think I may say with all confidence that that was a bargain that neither the Government nor your Board have any reason to be ashamed of [hear, hear]. I think that if we had gone deliberately, at an hour of great trial, and tried to get double the price from the British Government we should not be the honourable gentlemen which Mr. Newton has paid us the compliment we are. Besides, gentlemen, more than that we should have been very foolish if we had made the attempt. I hold in my hand—it is a very curious coincidence—that another price was £35,000, and if ours had been £36,000 I believe that we should have lost the contract and been standing face to face with what ultimately might have proved very formidable opposition. Therefore, in regard to what has been said by Mr. Newton—I believe that he has made his statement in all earnestness in the interests of the shareholders—he must give his Directors a little credit for looking a little further than he has done into this matter. We look on this fairly as a matter of business. We wished to make a bargain with the Government which would last, we wished to gain the goodwill of the Government, and we have done them justice, and we believe that they will do us justice in future [applause]. Now I think I have satisfied you, without any question, about that—that if we had said £36,000 we should not

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have had the contract. Now, what is the bargain? Hooper's Company at one time undertook to make and lay the cable for very much less. They undertook it, but did not do it. What we have undertaken to do we intend to do, and, as I have said before, the Telegraph Construction Company have shown their perfect confidence. Before these agreements have passed their respective Governments there is one ship on the ground, a second is near it, and I believe a third sailed yesterday to complete the cable up to Zanzibar. I know no other instance of such confidence, such energy, such enterprise, as is shown in the laying of this Cape cable [hear, hear]. Now, gentlemen, you who are associated in this Company ought to be proud of your Company and of the Directors for the way this business has been carried through [laughter, and hear, hear]. Now, gentlemen, Mr. Newton asks what interest we are to take in the company. We have said in the report £200.000 in shares. We shall put out, I believe, £200,000 of Eastern Company's debentures to meet these shares, and the holding of them will give us the entire control over the Company. As to the debentures, my impression is that the debentures are so good that the public will only be too glad to get them in any amount that might be offered. As to risks, they are shared entirely by the Telegraph Construction Company. Betwixt the two Companies and the Government there is a bargain which will stand examination in whatever form you look at it. I think I said that the work is being done even before the agreement is approved by Parliament, but there is no question that the British Parliament will approve it, and I don't think there will be one dissentient. And that, when you look at some of the contracts that go before Parliament, will show that it has been done in a very business-like way. Excuse me for taking some little credit to ourselves for this; but, looking at the way it has been done, I repeat that it has been done so well that when Mr. Newton stood up I thought he would congratulate us [hear, hear].

Mr. IRWIN: There is one thing that I should like to ask about as to the Telegraph Construction Company, and that is the cost per mile of the line? I see that £1,000,000 is asked for.

Mr. BURT: It is stated in the report that "The Telegraph Construction and Maintenance Company have engaged to manufacture and lay the cables, and provide a suitable maintenance ship, at a cost of £950,000, and the work is to be completed by December next. The following subsidies are to be paid by the respective Governments:—H. B. M. Government £35,000, Cape Colony £15,000, Natal £5,000, Portugal £5,000, making a total of £60,000."

Mr. IRWIN: But what is the mileage?

The CHAIRMAN: About 3,900 miles. I will just give you a contrast, as we are talking about telegraph business. This cable, nearly 4,000 miles in length, is to cost under £1,000,000, while there is a cable being made for the French people which is little more than half the length of ours, and that is to cost £1,000,000 sterling. Therefore I can only say that we must have made a good contract with the Telegraph Construction Company as compared with the contract the French Company has made.

Mr. NEWTON: Who are the other contractors?

The CHAIRMAN: Well, you who are so well posted up in telegraph matters, you need not ask me [hear, hear].

Mr. NEWTON: I have asked two questions of you—if you are contemplating making a limit, or making some proportion, between the debenture and the ordinary capital, I think that we ought to have some sort of guarantee that we shall not have these additions to the debenture capital. The other point is the interest of the Telegraph Construction Company? I wish to know if it is exactly with us—if they are going to take the ordinary shares, and will they hold them—supposing that the public do not support them, will they hold them? If they will I am quite satisfied, but, if not, I think that they have not that confidence in this work that they ought to have if they believed in it. I think the Eastern Telegraph Company and the Telegraph Construction Company should be placed almost as partners in the undertaking.

The CHAIRMAN: Just a few words. I don't think it would be judicious to go into details, but all I can say is that the interest taken on the part of the Telegraph Construction Company is much greater than on ours—it is, I may say, as two-thirds to one-third. The Telegraph Construction Company take a much larger interest. You are asking now to bind us about the debentures, and to alter articles of association. Bear in mind the particular property with which we are now dealing. I have never said that it is not an uncertain property—it is at the bottom of the sea, to a considerable extent beyond our control. Probably the Eastern's system is more under control than any system of telegraphy, but still something might occur that would render it necessary for us to raise money on debentures, and why should you try to bind us so that it would be impossible for us to move? We tell you everything, and you approve or disapprove. If you approve, we go forward; if you disapprove, we do not; and what is the use of altering articles of association that might be required to be altered at some time of great emergency?

Mr. NEWTON: At the risk of troubling the meeting—I should have no objection—but I tell you what you do. We have not the least power in the Company giving the debenture holders a vote, and then, sir, I am answered that so long as we have no vote at the meeting we are compelled to invest in ordinary capital if we wish to have a voice at this meeting. Give us votes on the debenture capital and I believe the debenture holders will be perfectly satisfied.

Mr. BURT: As a matter of course, a debenture holder, as such, has no right to speak here. But what is the position? You have £408,000 of debentures and a total share capital now of some £4,300,000. Mr. Newton knows very well that the ordinary proportion of debentures to capital as allowed by Act of Parliament is one-third; therefore, supposing that were to guide this Company, the Directors have a right to issue £1,099,000 of debentures instead of £682,000, as they have at present issued. I don't think the Directors have any idea of doing that, but if they had Mr. Newton will see that they have not exceeded the ordinary limit. And, supposing that they have votes, what would £682,000 be able to do against £4,000,000 odd?

Mr. NEWTON: The debenture capital is £640,000, not £408,000; the preference capital is £700,000, and the ordinary capital £3,697,000.

Mr. BURT: Well, it is £640,000 instead of £408,000; so there is £400,000 not issued.

The CHAIRMAN: I will now put the resolution, which has been read, and moved and seconded.

Mr. ROBARTS: There is to be a rebate on the messages passing over the lines from the Cape, and I should like to know what rebate.

The CHAIRMAN: I think I mentioned it in my introductory speech, that a rebate of one-half is to be given. For instance, if we earn £30,000 we give a rebate of £15,000, and we get £15,000 and all the working expenses of the system. That is the estimate of the rebate that we propose to give. Of course we cannot tell what the amount will be till we get into the working of the system; but we base the calculation on what we have done on the Australian and other stations. We carry so many messages, and we intend to give a rebate. We have a similar arrangement with the Eastern Extension Company, and with all these companies—it is a working arrangement, in fact.

The resolution was then put to the meeting, and carried with one dissentient.

The CHAIRMAN: I may mention in regard to this that your Board had not one letter recorded against this transaction, which is very remarkable. We have had sent to us proxies to a very large amount: and I must say just one word in regard to that. Mr. Newton said, why do you not give the debenture holders votes? All that I can say is that, judging from the number of proxies we receive at every meeting, I am very happy to say that the large bulk of our shareholders have the most perfect confidence in the working of the concern. Now, gentlemen, this concludes the business of the meeting.

The proceedings then terminated with a vote of thanks to the Chairman.

RECENT PATENTS.

3988. ELECTRIC LIGHTING, &c., *St. G. L. Fox.—Dated 9th October*, 1878. 6*d.*

To produce a light, the current passes through thin leaves or foil, preferably of platinum or an alloy of platinum and iridium. The lamp consists of two conductors, insulated from one another, having this leaf or foil stretched between them and in contact with each. For working a number of these lamps from a single source of electricity, from one pole of the electric generator proceeds a large conductor, from which branch out at various points where lights are desired smaller conductors, which again may have conductors branching off from them. The other pole of each generator is connected with the earth, so that the conductor and its branches and sub-branches will be perpetually in a state of electric tension tending to develop currents in every direction to the earth.

3991. ADAPTING THE ELECTRIC LIGHT TO DOMESTIC AND OTHER PURPOSES, *J. Clark.—Dated 9th October*, 1878. 4*d.*

In order to sub-divide a strong current, the main conducting wire if connected with a mercury bath, into which the ends of the other wires to receive the divided current are immersed. To produce the light, instead os solid carbon, carbon in a finely divided state is employed, and is placed between slips of glass or other transparent material. A corresponding set of wires terminates in a second mercurial bath, from which a prime conducting wire passes to earth or to the opposite pole of the battery.

4006. ELECTRIC LIGHTING APPARATUS, *P. Jensen—Dated 10th October*, 1878.—(*A communication.*) 6*d.*

Upon a vertical rod attached to a base plate is fixed a carbon holder, supporting a carbon cylinder which can turn on its axis. At the upper end of the rod is an arm carrying a tube with two grooved pulleys pressed together by springs. The carbon rod passes down the tube between the pulleys, and presses on the cylinder, the pressure being exerted by a rod with a weight attached, resting on the upper end of the carbon rod in the tube.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES JULY 16.	BUSINESS DONE WEEK ENDING JULY 16. Highest.	Lowest.
Anglo-American ......ex div.	53½, 54	54¾	54¼
Do. "B" ......ex div.	82½, ¾	85¾	85
Do. "A"	26¼, ¾	27½	26½
Brazilian	6¾, 7	6 15-16	6 13-16
Cuba	7¾, 8¼	—	—
Do. Ten per Cent. Preference	15½, 16½	16	15¾
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	10¾, 11¼	11⅛	11
Direct United States	10¼, ¾	10⅝	10¼
Eastern ......ex div.	7 11-16, 13-16	7¾	7¾
Do. Six per Cent. Debenture	105, 108	—	—
Do. Five per Cent. do.	103, 105	104	103¾
Do. Six per Cent. Preference ...x d.	11 13-16, 15-16	12	11¾
Eastern Extension ......ex div.	7 11-16, 13-16	7⅞	7¾
Do. Six per Cent. Debenture	108, 111	—	—
German Union	7¾, 8¼	—	—
Globe Telegraph and Trust	4 13-16, 15-16	4 15-16	4 13-16
Do. Six per Cent. Preference	10 15-16, 11 1-16	11	10¾
Great Northern	8¼, ½	8 7-16	8 5-16
Indo-European	20½, 21½	—	—
Mediterranean Extension	2½, 3	2¾	2¾
Do. Eight per Cent. Preference	9, ½	9½	9
Reuter's	9, 10	—	—
Submarine	227, 232	230	230
West India and Panama	1⅜, ⅝	1½	1 7-16
Do. Six per Cent. Preference	7⅞, 8⅜	8⅜	8¼
Western and Brazilian	3, ½	3⅜	3⅛
West. Union Seven per Ct. 1st Mt.	118, 122	—	—
Do. Six per Cent. Sterling	106, 108	—	—

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NOTES.

The Duplicate Australian Cable.—The SS. Scotia, with a portion of this cable, reached Aden on Tuesday, July 22.

The First of the Innocents.—One of the Companies so hurriedly formed for the introduction of the Electric Light has come to grief, and is in liquidation.

The Electric Light.—Niagara Falls are to be illuminated by electricity, the Prospect Park Company having contracted to supply the necessary apparatus.

Visit of Delegates to Liverpool.—The Delegates of the International Telegraph Conference left London on Wednesday morning on a visit to Liverpool, Edinburgh, and Glasgow. The visit will take about five days.

Society of Engineers.—Arrangements have been made for a visit of the members and associates of the society, on Wednesday, the 30th instant, to inspect the telegraph cable works of Messrs. Siemens Brothers, at Charlton, and the telegraph cable ship Faraday.

A Case of Blindness Cured by Electricity.—According to several American papers, a striking cure has been effected by Dr. W. B. Neftel, of New York; the patient being a lady, aged sixty-three, who had become blind in consequence of cataract. In regard to the *modus operandi*, we are only told that electricity was repeatedly applied in vicinity to the affected organ.

The Direct United States Cable Company (Limited).—At the meeting of the Board, held on July 18th, it was resolved to recommend a final dividend of 5s. per share, such dividend to be payable on and after the 16th August next, making with the interim dividends already paid, 5 per cent. for the year ending 30th June last, carrying forward £2,345 1s. 5d., after having carried to the reserve fund £34,756 4s. 3d., making it up to £100,000.

British Association for the Advancement of Science.—At the Sheffield meeting, which commences on the 20th of next month, there will be an important exhibition of scientific apparatus and specimens, both in the temporary museum and at one of the *soirées*. Inventors and others who may have objects of interest to exhibit are requested to communicate at once with the local secretaries of the British Association, Sheffield, and are reminded that this will be an exceedingly favourable opportunity of calling the attention of the scientific world to their discoveries.

Switzerland.—Under the New Constitution, the receipts from the telegraphs at first just about balanced the expenditure, but last year a great revenue was obtained, and a large one is expected this year. Thus, in 1874 the balance on the right side was 82 francs, in 1875 it was 10,539 francs, in 1876 the loss was 7,835 francs, but 1877 showed a gain of 6,713 francs, whilst 1878 gave a revenue of no less than 200,000 francs, and the sum entered in the estimates for 1879 is 175,000 francs. It may be that prudent motives will in the end obtain the ascendancy, then revenue from letters and telegrams will not be expected, and a gradual return will be made towards such a state of things as existed in 1874.

Telegraphy.—Quebec, June 28.—The Dominion Telegraph Company has been awarded a contract for the construction of the new shore line in the maritime provinces to connect lighthouses on prominent points with the telegraph system of Canada, in aid of which Parliament last session voted a bonus of 20,000 dollars. The construction of this line is the first step toward the completion of the scheme for connecting the Island of Anticosti and Magdalen Islands with the shores of the St. Lawrence by telegraphic communication, for which purpose Parliament has voted a subsidy of 15,000 dollars, to be continued annually. This system was inaugurated by Government with the view to rendering timely assistance to vessels in distress, thereby lessening loss of life and destruction of property.

The Telephone as a Lightning Indicator.—Mr. George M. Hopkins, of Brooklyn, N.Y., during a recent thunder storm, connected the gas and water pipes of his dwelling with an ordinary Bell telephone, and discovered that the electrical discharges were plainly indicated, either by a sharp crack or by a succession of taps. This occurred when the discharge was so distant that the thunder was inaudible. The sound also seemed to be perceived by the ear before the lightning could be seen. There was a marked difference in the character of the discharges, some that appeared single to the eye were really multiple. Often the discharges would consist of a series, beginning and ending with discharges larger than the rest, thus: —------—, sometimes it would be thus: —-----, sometimes the reverse, and often a single crack. The gas and water pipes were used, being the most convenient and at the same time the safest conductors for the purpose. Special apparatus might be devised, having a good ground, and a series of points for gathering the electricity from the air, but in using apparatus of this kind there is always more or less danger.

Uruguay.—The following short description of telegraph lines in this country will give an idea of the persistency of the Anglo-Saxon to have some connection with progress wherever and whenever it is to be found. Uruguay boasts of two principal telegraph companies—(1), the *Platino Brazilera*, the greater portion of which line is owned in England, and quite recently the direction has been transferred to London under the presidency of Mr. J. Pender, M.P., who has shown so much energy and ability in all that concerns telegraphy. The line is about 350 miles long, following a westerly direction from Monte Video to Santa Rosa, the latter place being close to the Brazilian frontier. The company also possesses a submarine cable line from Monte Video to the River Chui, halfway between Monte Video and the River Grande. (2) The *Oriental Telegraph*, extending from Monte Video in an easterly direction to the River Yaguaron on the Brazilian frontier. This line has little or no English capital involved in it. (3) The *River Plate Telegraph*.—This valuable property is entirely in English hands. The land line extends a distance of 150 miles from the city of Monte Video to Colonia, then per submarine cable to Ponta Lara (twenty-seven miles)

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on the opposite Argentine coast. There is, moreover, a direct submarine cable line from Monte Video to Lara (120 miles), and from thence to Buenos Ayres per land line. The total length of River Plate Telegraph Company's land line is about 177 miles, Submarine Cable line about 120 miles.

Electical Treatment of Writer's Cramp.—The disease known as writer's cramp, and the affections allied to it, such as telegrapher's cramp, musician's cramp, and that experienced by sewing-women and others engaged in occupations which draw severely and exclusively in certain muscles so as to induce weakness of the nerves in connection with them, have been investigated during several years by Dr. G. M. Beard, of New York. In a paper read by this authority before the Medical Society, the use of electricity locally applied is recommended as the foremost means of treatment. "Both galvanic and faradic currents," says Dr. Beard, "may be used—preferably the former. In some cases galvanization of the spine and neck, and what are called spinal-cord nerve-currents, are indicated. Strong galvanic currents, with metallic electrodes, I have used with advantage in some cases where mild currents seemed to do no good. The wire brush with the faradic current I often use, and in some cases electro-puncture. The relief from pain and fatigue that follows these electrical applications is immediate and uniform, and most grateful to the sufferer; and this temporary effect can be obtained even in the worst cases. I have not yet been able to demonstrate any very marked advantage from the rhythmical movements of the muscles in connection with the electrical applications." The author observes also that "electricity and hypodermic injections combined have made an epoch in the treatment of writer's cramp."

Telephones in Church.—According to the New York *Journal of the Telegraph*, a telephone has been placed in the Congregational Church at Mansfield, Ohio, the wires leading to the houses of several aged and invalid persons. A contemporary, in describing it, says it surmounts a floral decoration on the table in front of the open platform, where it is hardly seen. The speaker pays no attention whatever to it, yet every word uttered in the auditorium is easily heard in the rooms of the dwellings which the wires reach. The first message from the minister was from Scripture: "The word is nigh unto thee. His word runneth very swiftly." Recently, in a church in Richmond, Va., a transmitter was placed upon one of the pillars of the pulpit, almost entirely hid from sight. A small insulated wire ran down inside the pulpit rail and across the angle of a stair, up the wainscotting and along under the top rail, out through a gimlet-hole in the window frame and to the top of the parsonage, passing down through the ventilator into the chamber of an invalid young lady, where it was attached to the ordinary hand telephone. Imperceptibly to all around, the little instrument did its work, conveying to the ear of the patient sufferer the sounds of the well-known voice in the pulpit for the first time in long years. Of course the reverend doctor was anxious during the morning sermon, as his thoughts reverted to the distant listener, to know if she heard; and his pleasure may be imagined when he learned that the entire service—sermon, prayers, hymns, organ, and singing—had been audible to the person for whose comfort the arrangement had been planned.

The Light and Energy of Electricity and Gas.—In an article bearing this title in last week's *English Mechanic* Mr. J. T. Sprague closely criticises some of the scientific evidence placed before the Parliamentary Committee, especially that given by Sir William Thomson and Dr. Siemens. "Their statements (says Mr. Sprague) are all true, but so arranged as to constitute a complete chain of special pleading, and to convey an absolutely false impression of what the facts themselves really mean." For example, Sir William Thomson stated that "the energy which is actually used in the electric arc is about one horse-power per 2,400 candle-power;" whilst "one horse-power of energy in the combustion of gas produces about 12 candle-power." Upon this and the explanation afforded by the witness, Mr. Sprague very justly remarks: — "The statements are *true as to the energy actually in the lights*. The impression they produce *is false as to the energy necessary to produce the light*." Mr. Sprague accuses Sir William of having charged the gas light with the gross energy and the electric light with the net energy; and Mr. Sprague then proceeds to make what he considers an equitable comparison, using as far as possible Sir William's own figures:—"1 horse-power is 33,000ft.-lb. per minute, or 1,980,000 per hour. Expressed in heat units of 1lb. water 1° Cent., which equals 1,390ft.-lb., 1 horse-power per hour equals 1,424·5. This, then, is the potential energy of the 4 cubic feet of gas, giving 12 candles light. To put the 1 horse-power of energy into the electric arc, another 1 horse-power is of necesssity expended in the circuit and must be charged, because the gas compared with it is the whole amount necessary. But to produce 1 horse-power in a steam-engine involves a consumption of coal varying from 2·5lb. in the most perfect and expensive engines known, to 8 and even 10lb. in common engines; let us take 4lb. as a very fair engine's work, and we have 8lb. coal expended in generating the 2,400 candles mentioned. Now the potential energy of 1lb. of average coal is 13,000 heat units, or in 8lb., 104,000. Instead of having the energy per candle,

Gas	1,424·5	÷	12	=	118·7
Electricity	1,424·5	÷	2,400	=	·597.

This being what Sir W. Thomson makes it appear to be, we have by equitable comparison,

Gas	1,424·5	÷	12	=	118·7
Electricity	104,000	÷	2,400	=	43·3.

Even then we have omitted a very important element of consideration; the gaslight needs no machinery, no capital outlay, no skilled attendance; the electric light wants all these, and if they do not form an element of the scientific calculation as to potential energy involved in the two cases, they enter very largely as factors in the practical calculation as to the potential cost. Hence the difference in the practical and so-called scientific opinions noted in the committee's report." Similar observations are applied to the evidence of Mr. Siemens, who, according to Mr. Sprague, "commits a more serious injustice when he charges against gas the whole of the coal put into the retort allowing nothing for the coke and tar which form part of the actual cost with which he is comparing the gas. In this way he obtains a consumption of 15lb of coal per hour with gas, as against 8lb consumed in a steam engine to develop 1,000 candles in an electric arc." Mr. Sprague reminds his readers that he has obviously no desire to depreciate the importance of legitimate evidence favourable to the development of electric lighting; but in view of the sinister use which prospectus-mongers are likely to make of statements such as those published in the Parliamentary Report, he thinks it of great consequence that their actual meaning should be understood by the general public.

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ELECTRIC LIGHTING.

MOTIVE POWER ABSORBED BY GRAMME MACHINES.

BY HYPPOLYTE FONTAINE.

(CONTINUED FROM PAGE 101.)

An examination of the tables given below will explain why certain manufacturers find that their Gramme machines consume only two and a half horse-power, whilst others find that they absorb over four horse-power.

The velocity of the machine of course influences its efficiency; it would therefore be advantageous to augment considerably this velocity when much light is required, but, on the other hand, one is prevented from doing this owing to the length of the voltaic arc, which augments with the velocity, and which in practice should not exceed a certain dimension. When the arc has a greater length than 5mm., with carbons 13mm. in thickness, the carbons become too pointed, the positive one is but very slightly hollowed out, and the light continually varies.

If the arc were diminished, by compressing the regulating spring, the resistance would become too great,* and the machine would become unduly heated.

Generally speaking, in order to obtain favourable conditions for working, the distance between the points at which the light becomes extinguished should be ascertained, and the carbons should be adjusted to half this distance.

As will be seen from Table No. 3, the light obtained with a velocity of 1,000 revolutions is four times as great as that obtained with 700, and about twice that obtained with 800 revolutions. The power absorbed per 100 *becs* is 57·8 kilogrammetres, with 700 revolutions, and but little over 26 kgm., with 1,000 revolutions.

The results registered in the last column are very satisfactory; they prove that we may really obtain 285 *becs* per horse-power. This, we think, is the maximum that up to the present time has been observed in continuous working. We have surpassed this result only in a single experiment, by maintaining the maximum length of arc; but the light became frequently extinguished.

TABLE 3.

INFLUENCE OF THE VELOCITY OF THE MACHINE.

Number of revolutions per minute.	Length of the conducting cable.	Distance between the carbon points.	Luminous intensity in Carcel burners. Measured horizontally.	Luminous intensity in Carcel burners. Mean.	Power absorbed in kilogrammètres. Total.	Power absorbed in kilogrammètres. Per 100 burners of mean intensity.	Number of burners per horse-power.
700	100 m.	3mm.	160	320	185	57·81	130
725	100	3	243	486	165	33·95	220
750	100	3	295	590	192	32·54	230
800	100	4	365	730	230	31·65	235
850	100	5	488	976	282	28·89	270
900	100	6	576	1,152	330	28·64	260
1,000	100	10	646	1,292	338	26·16	285

TABLE 4.

INFLUENCE OF DISTANCE BETWEEN CARBONS.

Number of revolutions per minute.	Length of conducting cable.	Distance between carbon points.	Luminous intensity in Carcel burners. Measured horizontally.	Luminous intensity in Carcel burners. Mean.	Power absorbed in kilogrammètres. Total.	Power absorbed in kilogrammètres. Per 100 burners of mean intensity.	Number of burners per horse-power.
750	100m	5mm.	351	702	175	25	301
750	100	4	321	642	186	29	259
750	100	3	295	590	192	32·5	231
750	100	2	256	512	214	41·7	214
750	100	1	225	450	233	51·6	145
750	100	0	140	280	330	117·8	63

Table 4 shows the influence of the distance between the carbons when the velocity and the length of the conducting cable are constant. The maximum of intensity corresponds here to the minimum of power employed; but we observed that, with a distance between the carbons of 5mm., the light was unstable and the lamp became extinguished when the smallest variation took place in the velocity of the motor. The third experiment may be taken as a basis for working, as the light was very regular. When the distance between the carbons becomes nil, the light is produced only by incandescence; a high motive power is then required to produce a comparatively feeble light.

In Table 5 we have given the indications relative to the influence of the length of the cable upon the luminous intensity and the expenditure of motive power. The total motive power was as far as possible maintained constant; and, to avoid to rapid a fall in the luminous intensities, the velocity of the Gramme machine was augmented together with the length of cable.

TABLE 5.

EFFECT OF VARYING THE LENGTH OF THE CABLE (IN ALL THE EXPERIMENTS THE SECTION OF THE CABLE WAS 10 SQUARE MM.)

Number of revolutions per min.	Length of the conducting cable.	Distance between the carbon points.	Luminous intensity in Carcel burners. Measured horizontally.	Luminous intensity in Carcel burners. Mean.	Power absorbed in kilogrammètres. Total.	Power absorbed in kilogrammètres. Per 100 burners of mean intensity.	Number of burners per horse-power.
750	100 m.	4 mm.	321	642	186	28·9	267
800	150	5	345	690	230	33·3	225
825	200	5	315	630	232	36·8	178
850	300	5	275	550	225	40·9	183
900	400	5	260	520	231	46·3	162
950	500	5	245	490	230	46·1	160
1,000	750	5	236	472	243	51·4	145
1,100	1,000	5	215	430	256	59·5	126
1,350	2,000	5	160	320	230	71·0	104

With a cable of 2,000 metres, corresponding to a distance of one kilomètre between the machine and the regulator, we obtained only half the light which was observed with a cable of 100 metres. This result is one of vital interest in many cases of practice.

Our last experiments, recorded in Table 6, related to the influence of the duration of the working. They prove that at starting more power is absorbed, and more light is obtained; but that, after fifteen minutes' working, conditions are obtained which are altogether normal.

TABLE 6.

EFFECT OF LENGTH OF TIME OF WORKING.

Number of revolutions per minute.	Length of conducting cable.	Distance between the carbon points.	Period of Working.	Luminous intensity in Carcel *becs*. Measured horizontally.	Luminous intensity in Carcel *becs*. Mean.	Power absorbed, in kilogrammètres. Total.	Power absorbed, in kilogrammètres. Per 100 burners of mean intensity.	Number of burners per horse-power.
750	100m.	2mm.	At starting.	199	398	214	53·7	139
,,	,,	4	15 minutes.	180	360	183	50·8	147
,,	,,	,,	30 ,,	175	350	194	55·4	135
,,	,,	,,	1 hour.	181	362	191	53	142
,,	,,	,,	2 hours.	191	382	192	50·2	149
,,	,,	,,	3 ,,	190	380	190	50	150

The differences observed at starting are explained by the condition of the machine itself. The wires of the electro-magnets and the coils are then cold, their conductivity is greater and the inductive effect more considerable; then at the end of a short time the heating effect obtains its maximum. And, so far from continuously diminishing, the luminous effect increases somewhat when the working has continued for two hours.

To sum up: excellent working conditions are obtained, with the machine we experimented with, by using 100 metres of cable and giving to the voltaic arc a length of 3 mm. We then obtain a mean of 590 Carcel burners as diffused light, with an expenditure of 192 kilogrammètres (2·55 horse-power), which corresponds to 32·5 kilogrammetres per 100 Carcel burners, or to 234 burners per horse-power.

At the present moment a series of experiments is being made at Chatham with much more powerful machines, intended for use in military operations; we will describe the results obtained as soon as they are made known.

* The resistance of the coils of the machine, not that of the arc, is doubtless here referred to; the current would be too great to traverse the coils without heating them. If the higher velocity were not in other respects objectionable, we should say that the machine should obviously be constructed with coils of lower resistance.—ED. *E.*

ERRATUM.—In the heading to "Table 1," p. 101, in our last issue, the word "Siemens'" was, by an extraordinary printer's error, substituted for "Luminous."

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CONTRIBUTIONS TO MOLECULAR PHYSICS IN HIGH VACUA.*

BY WILLIAM CROOKES, F.R.S.

This Paper is a continuation of one "On the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules" (*see* Vol. II., pp. 59, 69), which was read before the Royal Society on the 5th of December last. The author has further examined the action of the molecular rays electrically projected from the negative pole in very highly exhausted tubes, and finds that the green phosphorescence of the glass (by means of which the presence of the molecular rays is manifested) does not take place close to the negative pole. Within the dark space there is absolutely no phosphorescence; at very high exhaustions the luminous boundary of the dark space disappears, and now the phosphorescence extends all over the sensitive surface. Assuming that the phosphorescence is due either directly or indirectly to the impact of the molecules on the phosphorescent surface. it is reasonable to suppose that a certain velocity is required to produce the effect. The author adduces arguments to show that within the dark space, at a moderate exhaustion, the velocity does not accumulate to a sufficient extent to produce phosphorescence, but at higher exhaustions the mean free path is long enough to allow the molecules to get up sufficient speed to excite phosphorescence. At a very high exhaustion there are fewer collisions, and the initial speed of the molecules close to the negative pole not being thereby reduced, phosphorescence takes place close to the pole.

Experiments are described in which a pole folded into corrugations is used at one end of a tube, the pole at the other end being flat, set obliquely to the axis of the tube, and having a plate of mica in front pierced with a hole opposite the centre of the pole. The questions which this apparatus was designed to answer are: (1) Will there be two sets of molecular projections from the corrugated pole when made negative, one perpendicular to each facet, or will the projection be perpendicular to the electrode as a whole, *i.e.*, along the axis of the tube? (2) Will the molecular rays from the oblique flat pole, when this is made negative, issue through the aperture of the screen along the axis of the tube, *i.e.*, direct to the positive pole, or will they leave the pole normal to the surface and strike the glass on its side? With the corrugated pole experiment shows that at high exhaustions molecular rays are projected from each facet to the inner surface of the tube, where they excite phosphorescence, and form portions of ellipses by the intersection of the planes of molecular rays with the cylindrical tube. When the oblique flat pole is made negative, a stream of molecules shoots from it nearly normal to its surface, and those which pass through the hole in the plate of mica strike the side of the tube, forming an oval patch of a green colour.

The oval patch in this apparatus happens to fall on a portion of the glass which has previously had its phosphorescence excited by the molecular discharge from the other corrugated pole. The phosphorescence from this pole is always more intense than that from the flat pole, and the glass, after having been excited by the energetic bombardment, ceases to respond readily to the more feeble excitement from the flat pole. The effect, therefore, is that, when the oval spot appears, it has a dark band across it where the phosphorescence from the other pole has been taking place. The glass recovers its phosphorescent power to some extent after rest.

In this apparatus a shifting of the line of molecular discharge is noticed. If the coil is stopped and then set going repeatedly, always keeping the oblique pole negative, the spot of green light occurs on the glass at the spot where it should come supposing the discharge were normal to the surface of the pole. But if once the flat pole is made positive, the next time it is made negative the spot of light appears nearer the axis of the tube, and instantly shifts to its normal position, where it remains so long as its pole is made negative. There seems no limit to the number of times this experiment can be repeated.

A suggestion having been made by Professor Stokes that a third, idle, pole should be introduced between the negative and positive electrodes, experiments are described with an apparatus constructed accordingly. The potential of the idle poles (of which there are two) at low exhaustions is very feebly positive; as the exhaustion gets better the positive potential increases, and at a vacuum so good as to be almost non-conducting, the positive potential of the idle poles is at its greatest. The result is that an idle pole in the direct line of fire between the positive and negative poles, and consequently receiving the full impact of the molecules driven from the negative pole, has a strong positive potential.

It is found that when the shadow of an idle pole is projected on a phosphorescent screen the trajectory of the molecules suffers deflection when the idle pole is suddenly uninsulated by connecting it with earth. The same result is produced by connecting the idle pole with the negative wire through a very high resistance, such as a piece of wet string, instead of connecting it with earth. A tube, which has already been described in a Paper read before the Royal Society on December 5th last, is used to illustrate this deflection. The shadow of an aluminium star is projected on a phosphorescent screen. So long as the metal star is insulated the shadow remains sharp, but on uninsulating the star by connecting it with an earth wire the shadow widens out, forming a tolerably well-defined penumbra outside the original shadow, which can still be seen unchanged in size and intensity. On removing the earth connection, the penumbra disappears, the umbra remaining as before.

It is also found that the shadow of the star is sharply projected when it is made the positive pole, the negative pole remaining unchanged.

These experiments are explained by the results just mentioned, that the idle pole, the shadow of which is cast by the negative pole, has strong positive potential. The stream of molecules must be assumed to have negative potential; when they actually strike the idle pole they are arrested, but those which graze the edge are attracted inwards by the positive potential and form the umbra. When the idle pole is connected with earth, its potential would become zero were the discharge to cease; but inasmuch as a constant supply of positive electricity is kept up from the passage of the current, we must assume that the potential of the idle pole is still sufficient to more than neutralise the negative charge which the impinging molecules would give it. The effect, therefore, of alternately uninsulating and insulating the idle pole is to vary its positive potential between considerable limits, and consequently its attractive action on the negative molecules which graze its edge. The result is a wide or a narrow shadow, according to circumstances.

After a definite shadow is produced, it is found that increasing the exhaustion makes very little change in the umbra, but it causes the penumbra to increase greatly in size. Experiments recorded in the Paper already quoted have proved that the velocity of the molecules is greater as the vacuum gets higher, and consequently the trajectory of the molecules under deflecting action, whether of a magnet or of an insulated idle pole, is flatter at high than at low vacua.

An experiment is next described, having for its object to ascertain whether two parallel molecular rays from two adjacent negative poles attract or repel each other. It is considered that if the stream carries an electric current, attraction should ensue, but if they are simply streams of similarly electrified bodies, the result would be repulsion. Experiment proves that the latter alternative happens, lateral repulsion taking place between two streams moving in the same direction.

Many experiments are given to illustrate the law of action of magnets on the molecular stream, but the results are of too complicated a character to bear condensation without the diagrams accompanying the original Paper.

The molecular stream is sufficiently sensitive to show appreciable deflection by the magnetism of the earth.

The author, after numerous experiments, has succeeded in obtaining continuous rotation of the molecular stream under the influence of a magnet, analogous to the well-known rotation at lower exhaustions. Comparative experiments are given with a "high vacuum" tube, where no luminous gas is visible, but only green phosphorescence on the surface of the glass, and a "low vacuum" tube, in which the induction spark passes in the form of a luminous band of light joining the two poles. These two tubes are mounted over similar electro-magnets, the direction of discharge being in a line with the axis of the magnet. Numerous experiments, the details of which are given in the Paper, show that the law is not the same at high as at low exhaustions. At high exhaustions the magnet causes the molecular rays to rotate in the same direction, whether they are coming towards the magnet or going from it, the direction of rotation being entirely governed by the magnetic pole presented to the stream. The north pole rotates the molecular discharge in a direct* sense, independent of the direction in which the induction current passes. The direction of rotation impressed on the molecules by a magnetic pole is opposite to the direction of the electric current circulating round the magnet. These results offer an additional proof that the stream of molecules driven from the negative pole in high vacua do not carry an electric current in the ordinary sense of the term.

The author, after giving details of experiments in which platinum and glass are fused in the focus of converging molecular rays projected from a concave pole, describes observations with the spectroscope, which show that glass obstinately retains

* Abstract of a Paper read before the Royal Society.

* Like the hands of a watch.

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at even a red heat a compound of hydrogen—probably water—which is only driven completely off by actual fusion.

The permanent deadening of the phosphorescence of glass is shown by projecting the shadow of a metal cross on the end of a bulb for a considerable time. On suddenly removing the cross, its image remains visible, bright upon a dark ground.

One of the most striking of the phenomena attending this research is the remarkable power which the molecular rays in a high vacuum have of causing phosphorescence in bodies on which they fall. Substances known to be phosphorescent under ordinary circumstances shine with great splendour when subjected to the negative discharge in a high vacuum. Thus Becquerel's luminous sulphide of calcium has been found invaluable in this research for the preparation of phosphorescent screens whereon to trace the paths and trajectories of the molecules. It shines with a bright blue-violet light, and when on a surface of several square inches is sufficient to faintly light a room.

The only body which the author has yet met with which surpasses the luminous sulphides, both in brilliancy and variety of colour, is the diamond. Most diamonds from South Africa phosphoresce with a blue light. Diamonds from other localities shine with different colours, such as bright blue, apricot, pale blue, red, yellowish green, orange, and pale green. One very beautiful diamond in the author's collection gives almost as much light as a candle when phosphorescing in a good vacuum.

Next to the diamond, alumina and its compounds are the most strikingly phosphorescent. The ruby glows with a rich full red, and it is of little consequence what degree of colour the stone possesses naturally, the colour of the phosphorescence is nearly the same in all cases; chemically prepared and strongly ignited alumina phosphoresces with as rich a red glow as the ruby. The phosphorescent glow does not, therefore, depend on the colouring matter. E. Becquerel* has shown by experiments with his phosphoroscope that alumina and many of its compounds phosphoresce of a red colour after insolation.

Nothing can be more beautiful than the effect presented by a mass of rough rubies when glowing in a vacuum; they shine as if they were red hot, and the illumination effect is almost equal to that of the diamond under similar circumstances.

Masses of artificial ruby in crystals, prepared by M. Ch. Feil, behave in the vacuum like the natural ruby.

In the spectroscope the alumina glow shows one intense and sharp red line less refrangible than the line B, and a faint continuous spectrum ending at about B. The wave-length of the red line is 6895.

The Paper concludes with some notes by Professor Maskelyne, on the connection between molecular phosphorescence and crystalline structure.

The crystals experimented on have been the diamond, emerald, beryl, sapphire, ruby, quartz, phenakite, tinstone, hyacinth (zircon), tourmaline, andalusite, enstatite, minerals of the augite class, apatite, topaz, chrysoberyl, peridot, garnet, and boracite. Of these, the only crystals which give out light are diamond, ruby, emerald, sapphire, tinstone, and hyacinth. The light from emerald is crimson, and is polarised, apparently completely, in a plane perpendicular to the axis. Sapphire gives out a bluish-grey and a red light polarised in a plane perpendicular to the axis. The ruby light exhibits no marked distinction in the plane of its polarisation.

Among positive crystals tinstone glows with a fine yellow light, polarised in a plane parallel to the axis of the crystal. So far, the experiments accord with the quicker vibrations being those called into play, and therefore in a negative crystal the extraordinary, and in a positive crystal the ordinary, is the ray evoked. Hyacinth, however, introduces a new phenomenon, being dichroic, the colours, in three different crystals, being pale, pink and lavender—blue, pale blue and deep violet, and yellow and deep violet-blue, polarised in opposite planes.

The only conclusion arrived at is, that the rays, whose direction of vibration corresponds to the direction of maximum optical elasticity in the crystal, are always originated where any light is given out. As yet, however, the induction on which so remarkable a principle is suggested, cannot be considered sufficiently extended to justify that principle being accepted as other than probable.

INTERNATIONAL TELEGRAPH CONFERENCE.

On Saturday last, July 19th, the members of the International Telegraph Conference were invited by the Joint Reception Committee of the Post Office and the Telegraph Companies to visit the volunteer camp at Wimbledon. About 100 ladies and gentlemen accepted this invitation, and in spite of the unfavourable state of the weather drove down to Wimbledon from London in well-appointed coaches and four. On arriving at the camp, between two and three o'clock, the visitors were entertained at luncheon in the south dining room of Messrs. Bertram and Roberts's refreshment pavilion.

Mr. Patey, President of the Conference, took the chair, and there were present, amongst others, General de Lüders, M. and Mdme. de Rego, Signor d'Amico, Sir W. and Lady Baynes, Etienne Musurus, Guilldani Effendi, Mr. and Mrs. Weaver, Dr. Brunner von Wattenwyl, M. Vinchent, Count von Wimpffen, Captain Mayne, R.N., C.B.; Colonel and Mrs. Du Plat Taylor, M. Nordlander, M. Neilsen, Mr. Erichsen, Sir James Anderson, Mr. Preece, Mr. Andrews, Admiral Selwyn, Mr. W. Gordon, M.P.; Mrs. and Mrs. Sabine, Major and Mrs. Wood, &c.

Luncheon being concluded,

The CHAIRMAN rose and said: The first toast I have to propose to-day will, I am sure, be drunk with great cordiality, not only by the English people here, but also by the friends from other countries we see around us. I give you as the first toast, "Her Majesty the Queen" [cheers].

The toast was drunk with enthusiasm.

The CHAIRMAN: This morning on getting up we saw the sun —a thing we have not had the pleasure of seeing much lately—and it augured well for the day, and even up to noon we had hoped to show our visitors Wimbledon as it usually is—with plenty of sunshine, a good deal of dust, and a good deal of noise. The day, however, I am sorry to say, has not turned out as we hoped it would have done. The rain has fallen, and I am afraid will continue to come down. We have looked forward to this day with pleasure because we wished to show our friends a truly national institution—the Volunteers, who have done so much for this country, under their most popular aspect and under the most auspicious circumstances. The Wimbledon meeting is a great national institution which is anticipated and talked about for some time previous to its occurrence in every town, village, and hamlet in England, Scotland, and Ireland, and the friendly struggle as to whom shall here prove himself the best marksman of the year, is watched by all Englishmen with great interest. At present we cannot tell you who is the Queen's prizeman, as the competition is yet unfinished, but we hope to show our friends some of the shooting and to witness the match between the Lords and Commons. I hope the weather will clear up, and that we shall be able to see something, but at any rate we are here to welcome our foreign friends [cheers]. They have come here from every part of the world, and it is a great pleasure to us that in spite of the unfavourable weather so many of them are now sitting round these tables [cheers]. We trust they will take away with them pleasant recollections of their visit to England, and an agreeable memory of this visit to the Volunteer Camp at Wimbledon. I now propose the toast of "The Foreign Delegates," who are now present [cheers], and I couple with the toast the name of Dr. Brunner von Wattenwyl [renewed cheering].

The toast was drunk with cordiality.

Dr. BRUNNER VON WATTENWYL who spoke in French, acknowledged the toast. After apologising for his ignorance of the English language, he said the foreign members of the Conference had profited by their stay in London to study this country and this nation while they had experienced the great hospitality of the English [cheers]. They admired the institutions and the great enterprise of England, which manifested her power, and they had also noticed the conservative spirit with which this nation dominated the spirit of the entire world. That day they had been brought to Wimbledon to witness English skill and courage, and it was now his privilege to propose a toast, which was "The health of their Chairman" [cheers].

The CHAIRMAN briefly responded.

M. NEILSEN, in proposing the health of "The Ladies," spoke in the most eulogistic terms of the fair sex, remarking that women as mothers, sisters, and wives, as daughters, or as daughters-in-law, were always charming, and were a blessing to men through life [cheers].

Mr. MACGREGOR, in responding to the toast, said he was highly flattered at being selected as the champion of the ladies. The ladies, as connected with Wimbledom, generally recalled to his mind visions of bright dresses, bright sunshine, and all that was enjoyable [cheers], but he was afraid that upon this occasion their chances of enjoyment were considerably damped.

The party then adjourned to the garden outside the dining room, where coffee and cigars were served.

Later in the day the visitors went round the camp and watched some of the shooting. They expressed their appreciation of what they were able to see, and shortly after six o'clock returned to London as they had come.

* "Annales de Chimie et de Physique," 3rd Series, Vol. lvii., p. 50.

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THE TELEGRAPH AND CYPRUS.

In our last number we noticed that the Eastern Telegraph Company had completed their land line communications in Cyprus. When the island was occupied by English troops as an advanced outpost in the East, the attention of many people was drawn in this direction. The majority of newspaper readers saw then and see now nothing but a desolate, pestilential island, without a first-class harbour, and doubtfully situated for good use in military operations; a few see it with faint and dim recollections of its past history floating in their minds, and fewer still connect past, present, and future. We believe and we hope that the completion of the inland telegraph is the first fruits in the recuperation of the island. So well has the route been selected, that we are informed the Government has adopted the same route for the roads to improve the ordinary means of communication through the island. Let us contrast its present condition with its past condition, and we shall see at once some of the steps necessary to restore its fertility.

According to Sir Samuel W. Baker, "Cyprus is divided into six districts; but according to its physical geography the island can be described by four. The principal port is Larnaca, in the central district (south). This is the landing-place of all first-comers, and creates the impression of wretchedness and treeless desolation, which is indelible. In the centre of this district is the capital, Lefkosia. On the extreme north is Morphu; in the south-east is the only real harbour, Famagosta. These principal towns are situated in the great desert-like plain of Messaria, which, although a famine-smitten area, of two-thirds the surface of Cyprus, in 1879, should be the chief cereal-producing portion of the island. It is difficult to describe the apparent sterility of this parched wilderness, and equally impossible for a new-comer to understand the actual value of a thistle-covered surface without a brook to moisten a line throughout the plain of dust, with river beds devoid of one drop of water; nevertheless, this apparent desert has been, and will be, the wealth-producing area of the country. Although the earth is parched by drought, there is at all times a supply of water within a few feet of the surface, which is supposed to be inexhaustible; thus the means of artificial irrigation should render Cyprus almost independent of precarious seasons."

The early history of the island, incorrect to some extent as it may be, tells a different tale. Eratosthenes speaks of it as discovered by the Phœnicians two or three generations before the days of Minos of Crete. It was at that time so full of wood that the land could not be tilled. At first the Phœnicians cut down the wood, and used it for smelting the copper, which was also abundant; but in after years, as their maritime supremacy increased, they used the timber of the island to build their ships. Cyrus the Great conquered the island and it was subject to the Persians till the reign of Darius, when an attempt was made, with some success, to shake off the yoke. About 58 B.C. it was seized by the Romans, and in the time of Augustus ranked among the pro-consular provinces. The Saracens conquered it in 648, and were driven out in 957, but soon after retook and retained it till subdued by the Crusaders. Then the island was brought into contact with England, through the chivalry of Richard I. The tale needs no retelling. It was held by the Lusignan family till 1570, when the Turks obtained possession, and held it till recent events brought it under the rule of England. Such, briefly, is the history of Cyprus, and its decadence in fertility has also been of the ordinary character. The first inhabitants, utterly ignorant of nature's laws, destroyed the forests which prevented the fierce action of the sun's rays upon the soil, and enabled it to yield an abundant crop with a minimum amount of moisture. A similar result has followed similar action. We have only to look at the present condition of Assyria, Syria, Palestine, Greece, parts of Italy, Spain, and America, for proofs of this, and readers of Marsh's "Man and Nature" will hardly fail to agree with him that the present sterility of these districts is due to a great extent to the lack of forests.

Is there any chance of Cyprus regaining its former fertile state? Sir Samuel Baker thinks there is. He says:—"This melancholy picture may be changed, and Cyprus may rapidly assume a position of importance. There is an absolute necessity for irrigation works, and the inhabitants are per-

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fectly able and fully prepared to carry out upon their native plans the various systems for obtaining water. A water-wheel and two oxen will raise sufficient water to irrigate forty acres per annum. The cost of erection and the price of the animals will be £20. Thus an expenditure of 10s. per acre will insure the crop and render the farmer independent of seasons. If the Government will advance the capital at 6 per cent., secured upon mortgage, the cultivator will be relieved from the usurer (to whom he is now the slave), his farm will prosper, and the revenue of the district will benefit by the increased production of the land, which is the wealth of Cyprus, now rendered precarious through the want of water. The Cypriotes are exceedingly clever in discovering springs and making them available for irrigation by means of a series of many hundred wells connected by subterranean tunnels, which conduct the water from great distances to the desired level. All that is required is monetary assistance. The amount should be expended in native labour, to benefit the island, and the introduction of foreign machinery, with the necessary abstraction of local capital to enrich contractors, should be specially avoided. It is generally believed that the destruction of forests has affected the climate and reduced the rainfall of Cyprus. This may be the case to a certain extent, but the close proximity of the great range of mountains in Asia Minor, within 70 miles of the northern coast, must by superior attraction and the low temperature of the higher altitudes seriously interfere with the rainfall of this island. From the numerous vestiges of ruined aqueducts and other waterworks, I am of opinion that the ancient prosperity of Cyprus was the result of artificial irrigation, and that the seasons were exceedingly precarious.

"There can be no doubt that the first necessity is water; without a regular supply the general fertility of the soil is negatived. The revenue is dependent upon agricultural productions, which are equally dependent upon irrigation; thus the first duty of our rule is the development of the water resources of the island, which would in a few years change the sterility of the Messaria into the fertility of a vast plain of verdure."

We are told that the Government recognises the lack of forest land as detrimental to fertility; and not only are trees planted as preservatives or preventatives of miasmic influences, but are planted also to replace those so long destroyed. The telegraph lines, again, form the lines along which these trees are being planted, and so, again, show how carefully those who had charge of the work considered and matured their plans.

CORRESPONDENCE.

ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me to offer a few remarks with respect to the concluding paragraph of the leading article in your issue of July 12th. I venture to think, in accordance with what the writer of the article suggests as possible, that there is no real ground for the objection felt by some electricians to the use of the term electromotive force. It is quite true that it is not a force in the mechanical sense, viz., a thing which acts like the muscles of animals, producing in matter either strain or acceleration; but then if it were there would be no need to prefix the qualifying adjective *electromotive*. Force proper is of only one kind, and requires no prefix; but as it causes ordinary matter to move it might be distinguished as *matter-motive force*, or, as Professor Chrystel calls it in his article in the *Ency. Britt.*, "*pondero-motive force*." Something there certainly is, however, which has no action on ordinary matter, but which produces electric currents, *i.e.*, causes electricity to move, and a very reasonable name for this something is electromotive force. What it is we don't know, and cannot till we know what electricity is. It is not ordinary force, but neither is it the square root of it, nor anything of the sort, any more than a quantity of electricity is the square root of a force multiplied by a length.

One form of E.M.F. is difference of potential; or rather wherever there is difference of potential there also is an E.M.F., which is measured by that difference of potential; but there are other modes of producing it. So, also, one form of water-motive force is difference of level; or, rather, wherever there is difference of level there also is a water-motive force which is proportional to that difference of level; but there are other modes of producing it, *e.g.*, pumps. A battery is like a pump, or like a dredging machine, continually raising the potential or level on one side and allowing it to flow back through the rest of the circuit.

It seemed to me, therefore, that Mr. Baynes's suggestion of the term potential difference as a substitute for the far more general term E.M.F., was a mistake, a conclusion supported by Prof. Clerk Maxwell's excellent letter.

The unpleasantness of using the term *force* in any other sense, however qualified, than that of common mechanical force may be avoided by using the initials E.M.F. simply, the connotation of the last letter being disregarded. Or, perhaps, the non-mechanical force might be spelt with a ph!—Yours, &c.,

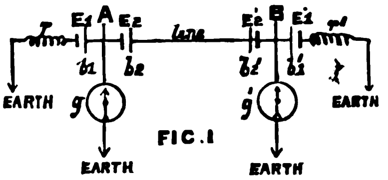
OLIVER J. LODGE.

ON RECENT IMPROVEMENTS IN DUPLEX AND QUADRUPLEX TELEGRAPHY.

BY G. K. WINTER, F.R.A.S., AND ALEXANDER MUIRHEAD.

In the issue of this Journal for April 19, 1879, appeared a letter from the late Mr. Brough, calling in question the novelty and efficiency of that part of the improvements recently patented for us by Mr. John Muirhead, Jun., which is attributed to Mr. Briggs; and mention is made of what has been done by Mr. Oliver Heaviside in the same direction. To enable the readers of this Journal to understand the matter, we will give, by way of preface to this Paper, an extract from Mr. Heaviside's Paper in the *Philosophical Magazine* for June, 1873, describing the then newly-invented methods which are referred to by Mr. Brough:—

"I will now describe two original methods of duplex working, which, though, perhaps, not quite so easily put into practice as the foregoing, may be interesting from the theoretical point of view.

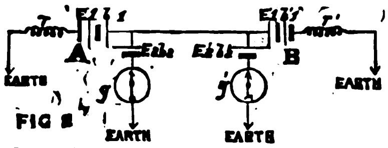


"As in the bridge arrangement, the outgoing currents do not pass through the receiving instruments at all. In the first of these plans, as shown in Fig. 1, the receiving instrument at each station is connected between the middle of two batteries and the earth. r and r^1 are rheostats. The condition that the batteries E_1 and E_2 at station A cause no current in g is that

$$E_1 : E_2 = r + b_1 : b_2 + a,$$

a being the exterior resistance as before, and similarly for the other station. The strength of current sent to line is

$$\frac{E_1}{r + b_1} \text{ or } \frac{E_2}{b_2 + a}.$$



In the second plan, shown in Fig. 2, one of the batteries at each station (E_2 and E_2') is placed in the same branch as the receiving instrument, and both E_1 and E_2 tend to send the same current to the line.

"When $E_1 : E_2 = 1 + \frac{r + b_1}{a}$ (a having the same meaning as before) the electromotive force E_2 is neutralised, and there is no current in g. The line current is $\frac{E_1}{r + b + a}$.

"I have adapted these plans to the direct writing Morse by

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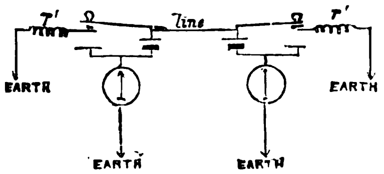
using an ordinary reversing key (which is nothing more than two keys insulated from each other, and worked by the same lever), in order to put the two batteries E_1 and E_2 simultaneously in and out of circuit. I also found it necessary for there to be no interval of disconnection, but did not find it necessary to introduce equivalent resistances when they were out of circuit, though theoretically this should be done, and the same key could be made to do it."

The first of the plans above described, and shown in Fig. 1, which is very similar to one of Gintl's methods, has recently been reinvented in a modified form by Mr. Briggs, of the Indian Government Telegraph Department. Fig. 3 shows his arrangement.

FIG. 3

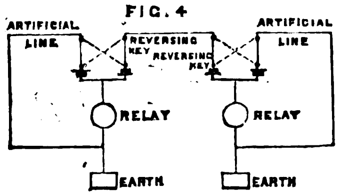


It will be seen that, according to this plan, when the keys are at rest, the batteries are connected to the resistances and the line exactly as in Fig. 1, but that when the key, say at A, is depressed to give a signal, the batteries at that station are short-circuited, and hence rendered inactive; but, as they were sending no current through the instrument at A, the fact of their being cut out in no way modifies the electrical state of that instrument as controlled by the batteries at B.

This plan is simpler than Heaviside's, and has been working exceedingly well on some of the Government lines in India. But we prefer to use a reversing key instead of the short-circuiting key, so that the batteries, instead of being merely put alternately in and out of circuit are kept continually in circuit, but act alternately in opposite directions as regards the true and artificial lines.

In this arrangement perfect balance is obtained when the true and artificial lines are equal, and balance is perfectly independent of any changes in the resistance and electromotive forces of the two halves of the battery, any inequality in which will merely cause a current to flow through the receiving instrument, but which current will remain the same whether a signal is being sent or not—that is, whether the battery is direct or reversed. The arrangement will be understood from Fig. 4. In the reversing keys the continuous lines represent the connections when the keys are at rest, and the dotted lines those when the keys are depressed. These reversing keys are of ordinary and well-known construction.

FIG. 4



It will be seen that as far as the receiving instrument and batteries are concerned, it is really the true and artificial lines which are affected by the reversing key. They mutually replace one another in two portions of the circuit external to the instrument and batteries. There has, therefore, been given the name of double substitution to this form of duplex working, which, although similar in appearance to the split battery system, differs from it essentially in principle, for whereas in the split battery system balance depends on the maintenance of a strict proportion between the electromotive forces of the two halves of the battery and the resistance of the true and artificial lines, the balance in the method of double substitution depends only on the equality of the true and artificial lines, which, however, experience shows may differ widely without affecting the received signals injuriously.

The principal merits claimed for this plan are:

1. Its very wide working range. The artificial line may be altered within wide limits without affecting the signals.

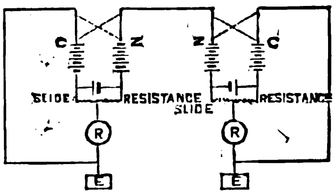
2. The fact that the plan requires no special winding of the coils as in the differential system.

3. That the sensitiveness of the relay is not reduced, and magnetic retardation increased, by the shunting action of bridge wires, as in the bridge plan.

4. The balance, as stated above, is not disturbed by variations in the electromotive forces or resistances of the two halves of the battery, as is the case in the ordinary split battery system—that is, when the battery is cut out of circuit by a short-circuiting key, or the two halves of the battery put simultaneously into and out of circuit according to Heaviside's plan. In addition to this, the action of the signalling on the distant instrument is of course doubled. All that is necessary to neutralise any current which may be passing through the receiving instrument in consequence of inequality in the two halves of the battery is to join the receiving instrument slightly out of the centre of the battery. In order to do this effectually, we shunt two or more of the middle cells of the battery by a slide resistance equal to about three or four times the resistance of the cells so shunted, the receiving instrument being joined between the contact point of the slide and earth.

Fig. 5 represents the arrangement with the slide resistance.

FIG. 5



In describing the nature of our improvements in quadruplex telegraphy it will be convenient, firstly, to describe the method of double sending—that is, sending two messages at the same time in the same direction, or biplex telegraphy; and then, secondly, to describe the way in which the method of double substitution has been applied to duplexing the biplex methods. The biplex arrangement:—

There are at the transmitting station two keys, one for the use of each operator, and so arranged in connection with batteries that in the several positions of the keys the battery strengths applied to the line are as follows:—

Both keys at rest	+ 3
Key B depressed, A at rest...	+ 1
Both keys depressed	— 1
Key A depressed, B at rest...	— 3

This series of battery powers is identical with that which has been adopted by one of us (Winter) ever since 1875, and was fully described in a pamphlet.

At the receiving station there is a polarised relay adjusted to break the local circuit when the current is plus, and to complete it whenever the current becomes minus; a local sounder or other receiver connected with this relay records the depressions of key A. There is also in the main current at the receiving station a double-tongued relay, which is used for completing the circuit of the sounder or receiver intended to respond to the movements of the key B. This double relay, which forms an important feature in our system of quadruplex, is so arranged that, in order that the local circuit should be completed, it is necessary for both tongues to be against their respective contact points. To accomplish this either the tongues are insulated and the contact between tongue and tongue caused to be completed through the contact points, which, in this case, are connected electrically with each other, or the contact points are insulated, and the contact between point and point is completed through the tongues, which, in this latter case, are, of course, connected together. The polarity and adjustment of the tongues is so arranged that the contact between one tongue and its point is only broken when the current is + 3, and that between the other tongue and its point is only broken when the current is — 3. With the intermediate strengths of + 1 and — 1, both tongues are in contact with their points, and the circuit of the relay is complete. Thus the local circuit is broken when the current is either + 3 or — 3, but it is closed when the current is either + 1 or — 1. Both the contact points are fixed to the same carrier, and things are so arranged that, when once the contact points have been individually adjusted, their further adjustment for ordinary changes in strength of the currents is made simultaneously by one and the same motion of the carrier. On very long lines it may be necessary to use a local relay to work the recorder, the local circuit of this second relay being completed by the relay just described, but this will not be generally necessary.

Figs. 6 and 7 represent respectively a plan and section of one form of the double relay. In this form both tongues, C C, play between the same pole pieces, A A, of the electro-magnets B B. The tongues are polarised oppositely by a permanent magnet, D D D, so arranged that one end of it polarises the upper tongue and the other end polarises the lower tongue. The electro-magnets are placed horizontally one on each side of the tongues, and at right angles to them. The pole pieces A A of the electro-magnets are flat pieces of soft iron of the same width as the core, and continued vertically above and below the cores across the flanges sufficiently far to envelop both tongues in their action. The tongues are caused to play as nearly as possible at equal dis-

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tances above and below the axes of the cores, so that the action on them may be as uniform as possible. The contact points are on the same side of the carrier, and one above the other. They are insulated from the frame work of the relay and from each other, contact between them being completed through the tongues when both tongues are against their respective contact points.

FIG. 6.

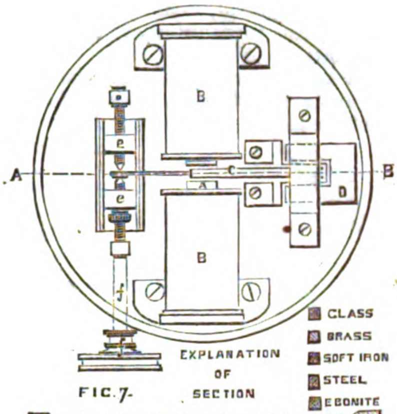
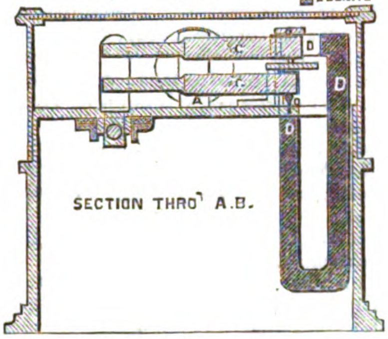


FIG. 7.



The three positions of the tongues, corresponding with the currents + 3, + 1 (B depressed), and — 3 respectively, are shown in Fig. 8.

FIG. 8.

After the first adjustment of the tongues their further adjustment is made by moving the whole carrier, *e e*, by means of the slow motion screw, *f f*, which works in a nut underneath the carrier.

It is evident that the action of any current passing through the coils of the electro-magnets is to cause the electro-magnets to act oppositely on the upper and lower tongues in consequence of the opposite polarity; thus, if a plus current tends to cause the upper tongue to move in the direction of its insulated point, a minus current will have the same effect on the lower one. The adjustment of the tongues is such that it requires a strength of + 3 to act thus upon the upper tongue, and — 3 to act in the same way on the lower tongue. If the current has either of the intermediate strengths of + 1 or — 1, the strength is insufficient to move either of them against the bias given them against their contact points, and consequently both tongues are in contact with their respective contact points, and the local circuit of the relay is complete. When the current changes rapidly from + 3 to — 3, the lower tongue leaves its contact point before the upper tongue has time to make contact. It is only when this change is retarded that any difficulty is experienced in working the local instrument B direct with this relay. If the instrument is a recorder the signals are perfect, as the effect of retardation is only to cause a slight trembling of the armature against its upper limiting stop, and is insufficient to affect the record. With sounders there is an inconvenience which can be remedied by using an extra local relay to complete the circuit of the sounder, the local circuit through the coils of which extra relay being completed by the double relay we have described above. This arrangement will probably only be found necessary on very long lines, or where any considerable length is submarine or subterranean.

Another form of double relay, which we have found to be equally good, and in some respects more convenient, is shown in Figs. 9 and 10.

In this form the tongues, C C, are polarised in the same sense by the permanent magnet, D D. The tongues in this form are insulated from the frame work of the relay and from each other, and contact between them is established when both tongues are against their respective contact points, which, as in the former case, are fixed to the same carrier and the same side of it, but they are uninsulated. The electro-magnets, E E E E, are in this case polarised by the ends of the two permanent magnets D D, the other poles of which polarise the tongues, so that all four cores and pole pieces have the opposite polarity to that of the tongues C C, which play between them. The action of the currents on the tongues is in this case precisely similar to that which we have already explained in reference to the other form of relay. In this case, however, the polarity of the two tongues is the same, but the polarities of the pole pieces between which they play are affected by the current in opposite sense, and, consequently, opposite motions result in the tongues, as in the former case.

FIG. 9

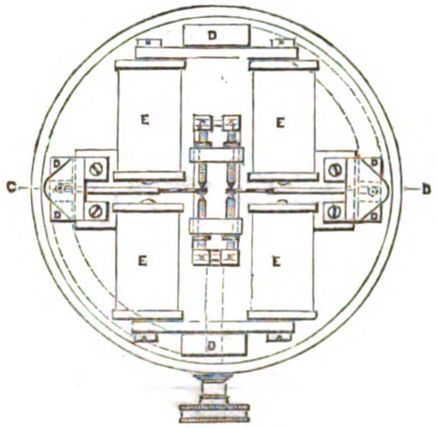
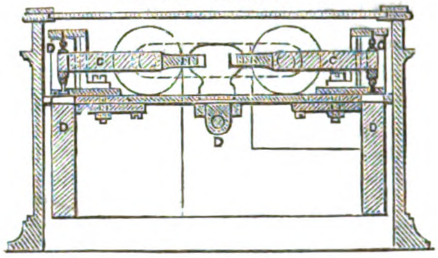


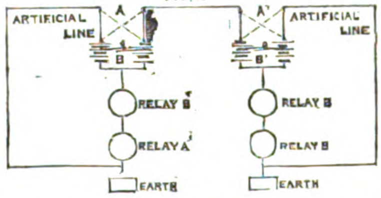
FIG. 10
SECTION THRO C.D



Both forms of relay we have described have worked with perfect success on the line between Bombay and Madras, a distance of about 800 miles without translation. They may, of course, be much varied in shape and detail, but it would seem that it is necessary that the electro-magnets should be small, probably the smaller the better within reasonable limits.

We now come to explain how the double sending or biplex system is duplexed. We apply the method of double substitution, which, in its simple form, we have already described, in either of two ways,—

FIG. 11



1st. The batteries and keys may be joined as shown in Fig. 11. In this figure, A A[1] are reversing keys, and B B[1] are simple short circuiting keys. By closing the key B or B[1] the battery is reduced from 3 *n* cells to *n* cells. By pressing the reversing key A or A[1] the battery, whether of the power of *n* or 3 *n* cells, is simply reversed. The relays are placed between the middle of the battery and earth.

2nd. The batteries may be joined up with two reversing keys at B B[1], as in Fig. 9. In this arrangement the keys B and B[1] separate the batteries into two portions, of which one contains 2 *n* cells, and the other *n* cells. When these keys are at rest the connections are along the continuous lines, and the two portions of the batteries are acting in the same direction, so that the current is $2n + n = 3n$. When these keys are depressed

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they reverse n cells of the battery, so that there are only $2n - n = n$ cells acting. The keys A and A^1 when depressed, simply reverse the current, whether it is $3n$ or only n as before. The mechanical construction of the keys (which are such as are well known as reversing keys) and the detail of these connections is shown by Fig. 12*a*.

FIG. 12

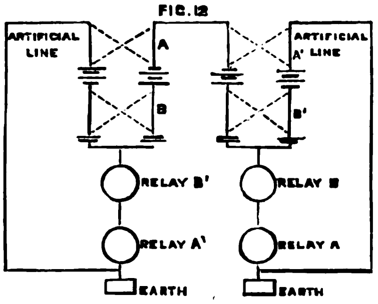
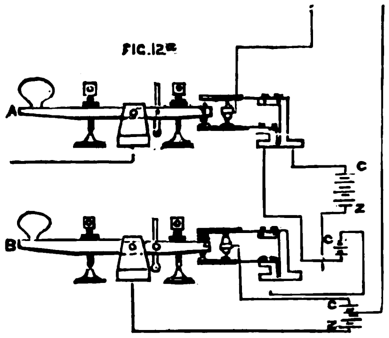


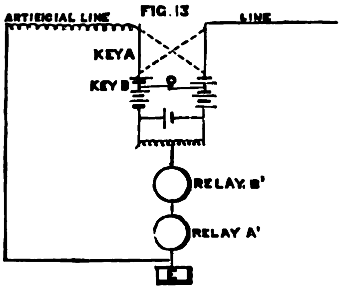
FIG. 12a



Although these plans have only been described as giving the ratio + 3 to + 1 as the battery powers employed, yet it is obvious that by changing the position of the keys B, B^1 the ratios may in either plan be altered as desired.

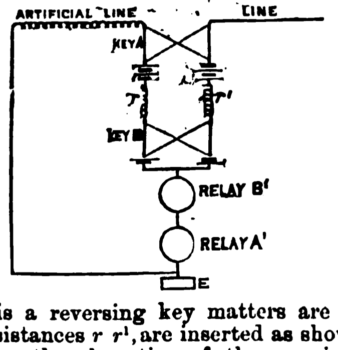
Where there is a want of uniformity in the batteries, balance may be perfect for key A, but imperfect for key B. When key B is a short circuiting key this may be remedied in the following way, see Fig. 13.

FIG. 13



A few cells may be placed between the two halves of the battery, and these cells shunted by a slight resistance. It is evident that the adjustments of this slide will not affect the balance as far as key A is concerned, but it will affect the balance for key B; in practice therefore the artificial line is first adjusted to obtain balance when key A is worked, and the balance for key B is then adjusted by means of the slide.

FIG. 14.



When key B is a reversing key matters are arranged as in Fig. 14. Two resistances $r\ r^1$, are inserted as shown in the figure. It is evident that the alteration of these resistances will not affect the balance as far as key A is concerned, but it will affect the balance when key B is worked, as these resistances are external to this key. The artificial line is therefore first adjusted to obtain balance when key A is worked, and the resistances $r\ r^1$, are then adjusted, so as to obtain balance when key B is worked.

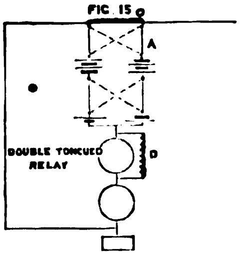
These resistances may be conveniently arranged, so that one is increased and the other decreased, and *vice versâ*, simultaneously.

These arrangements will not be found generally necessary, but they are useful as a precautionary measure in case the batteries get into bad order.

It is, of course, very essential that the reversal of current through the double relay should be as rapid as possible, and as on long lines the tendency of the capacity of the wires is to cause a retardation in this reversal, it is advisable on such lines to adopt the following plans to counteract, as far as possible, the effect of this retardation.

1st. Connection may be made across the reversing key A, between the true and artificial lines, the wire forming the coils of an electro-magnet, as shown at C in Fig. 15.

FIG. 15



2nd. The wires of a second electro-magnet may be connected as a shunt on the double tongued relay, as shown at D in Fig. 15. It is advisable that the resistance of the electro-magnet at C should be at least equal to twice that of the line, and that at D at least equal to that of the relay it shunts. The electro-magnets may be of the closed horse shoe form, as shown in section Fig. 13. Or they may consist of a single rod of soft iron, with flanges also of soft iron, and a cylindrical casing of iron closing over the wire, and connecting magnetically flange with flange, as shown in section in Fig. 14.

When it is necessary to compensate for static induction it is preferred to use Muirhead's inductive resistance for the artificial line.

By carrying on the same principle further the quadruplex arrangement may be added to and made multiplex, thus, for instance, in triplex telegraphy, which may be duplexed, three keys are employed, and the currents are arranged as follow:—

Let *a*, A, — *b*, B, — *c*, C, represent the three keys, the small letters meaning that the key is at rest, and the capital letters that the key is depressed; then currents are—

+ 7 ———	*a*, *b*, *c*.
+ 5 ———	*a*, *b*, C.
+ 3 ———	*a*, B, C.
+ 1 ———	*a*, B, C.
— 1 ———	A, B, *c*.
— 3 ———	A, B, C.
— 5 ———	A, *b*, C.
— 7 ———	A, *b*, *c*.

The recorders corresponding with A and B are worked as in biplex telegraphy, while that corresponding with C is worked with two double tongued relays, or one relay with four tongues, which is better. Two tongues complete the local circuit between + 5 and — 5, the other two tongues short circuit the recorder at + 1 and — 1. Or one pair of tongues may close or open the circuit between + 5 and + 3, and the other pair may close or open it between — 3 and — 5. In either case a relay acted on by the local circuit of this compound relay is required to work the recorder. It is of importance that the electro-magnets in the double or quadruplex tongued relays should be small.

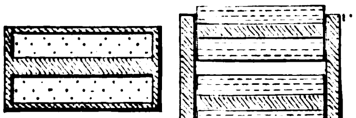


FIG. 17 FIG. 16

EXPLANATION
SOFT IRON
WIRE

The quadruplex system above described was tried successfully on a loop line from the Central Telegraph Station, London, to Birmingham, which was composed of a considerable length of underground wire. This circuit was readily balanced by means of a length of Muirhead's inductive resistance, equivalent to 20 knots of ordinary underground wire at the commencement of one artificial line and 14 knots at that of the other.

Between Madras and Bombay (800 miles) the double-substitution plan of duplex has been worked successfully without any intermediate translation, and arrangements are now being made to put the quadruplex system, based on the same principle, on a lengthened trial between these stations.

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THE ELECTRIC ARC—ITS RESISTANCE AND ILLUMINATING POWER.

BY PROFESSORS ELIHU THOMSON AND EDWIN J. HOUSTON.

From a series of investigations made by us in the winter of 1877-78, and published in the *Journal of the Franklin Institute* for May and June, 1878, as part of the report of the Committee of the Franklin Institute on Dynamo-Electric Machines, we were led to infer the existence in the electric arc of certain relations between resistance, current strength, and illuminating power. Further experiments in the same direction have seemed to confirm these relations. We therefore have taken the opportunity of stating them, believing that they will be of value to other investigators in this field.

The relations existing between arc resistance and current strength, and between current strength and illuminating power, are apparently expressed by the following laws, viz.:

1. *In arcs of equal lengths the resistances are inversely proportional to the current strengths.*
2. *The illuminating power of an arc is approximately proportional to the current traversing it.*
3. *In arcs of equal length the total energy given out is proportional to the current strength.*

Whether the above laws will be established for great range of conditions remains for future investigation; and, indeed, when it is considered that it is almost impossible to maintain arcs of equal lengths, the results may be regarded as approximately true, and point to the need of an extended series of experiments, in order that the errors in individual cases may be eliminated. The experiments we are now conducting in this direction are not yet complete, and embrace, besides the laws just stated, other interesting relations. We have thought, however, that the results thus far obtained justify the publication of the above statements of existing relations.

The following theoretical considerations, aside from experimental data, serve partly to explain the first law. An increase of current is attended by a more active transference of carbon vapour from positive to negative electrode, which would result in an increased breadth of arc and, consequently, decreased resistance.

The bearing of this law on the question of the economical division of the electric current in the production of several arcs in the same circuit, instead of one single arc, is important. It has been held by some that if the intensity of the current be halved, the work being as the square of the current, economic division is impossible. It must not, however, be forgotten, as appears to have frequently been the case, that the above statement assumes that the resistance is constant. With the arc, however, the resistance with a changed current is not constant. If the current be doubled, its resistance is halved; if the current be halved, its resistance is doubled—always assuming the distance between the electrodes to remain constant. The work of the current, therefore, with a given length of arc, is proportional to the current, and not to the square of the current, as has been frequently assumed. The third law expresses this relation, the total energy being the work given out as light and heat, and due to current traversing resistance, which resistance falls as the current increases, and the converse.

The total energy evolved in an arc does not, however, appear to be a measure of the illuminating power of said arc, it having been noticed by us that the total energy in the arc may be the same, while the illuminating power varies considerably. The illuminating power of arcs representing equal amounts of energy evolved, appears to be affected considerably by the distance apart of the carbon electrodes. It is found in practice that in any case, the maximum illuminating power is obtained when the electrodes are separated to a certain distance. An increase of this distance between the electrodes is attended by an increase in the resistance of the arc and by a decrease in the current strength, not, however, proportional to the increased resistance. Consequently, an increase in the total energy evolved in the arc may take place while an actual decrease of the illuminating power has resulted. This last statement may at first appear to involve a contradiction, but when it is remembered that the greater portion of the light evolved by an arc comes from the intensely heated surfaces of the electrodes, and not from the heated gas stream constituting the arc proper, it can be readily understood that with a large arc, a considerable proportion of the energy will be expended in sustaining the temperature of the gas stream and supplying or making good the heat convected from it to the surrounding air. In an arc of less length, a smaller proportion of the energy is expended in sustaining the temperature of the gas stream, and the amount of surface of the electrodes heated to intense incandescence is relatively increased.

It is our opinion that the relation between the illuminating power and the current, as expressed by the second law, is necessarily quite approximate, since the distance apart and consequent facility for loss of heat by convection from the electrodes cannot be without influence on the illuminating power.

Central High School, Philadelphia,
June 13, 1879.

MAGNETIC DECLINATION AND HORIZONTAL FORCE.*

BY WILLIAM ELLIS, F.R.A.S.

In this Paper the author draws attention to the long series of magnetic observations which have been made at the Royal Observatory, under the direction of Sir George B. Airy, K.C.B., Astronomer Royal. Commencing in the year 1841, the observations for a few years consisted of eye readings of the various instruments, made every two hours; since the year 1848 the motions of the magnets have been registered by photography, according to a plan arranged by Mr. Charles Brooke.

Attention is briefly drawn to the question of magnetic variations, and to the circumstance that examination of the Greenwich records shows that, in addition to the ordinary diurnal and annual changes, there appears to exist, in the magnetic diurnal ranges, an inequality of marked character, and of longer period, resembling in its features the well-established eleven-year sun-spot period.

It is remarked that this is not, by any means, the first time that such relation has been discussed, it being, by some investigators, considered to be already sufficiently well proved. But it appeared to the author that the long series of Greenwich observations might be well applied as an independent test of the accuracy of the supposed relation. For (as regards the results actually employed) the observations have been throughout made on the same general plan, and with the same instruments. The conclusion arrived at should therefore be one worthy of some confidence.

The results for declination and horizontal force only are used, because, the vertical force instrument having been more than once changed, the strict continuity of the record by the latter instrument is somewhat broken.

The monthly mean diurnal range of declination, or of horizontal force, is taken to represent the magnetic energy of the month relatively to other months. Two series of numbers are thus formed, each series being treated independently. Days of unusual magnetic disturbance are omitted.

Before the numbers can be compared with sun-spot numbers, it is necessary, in order to estimate progressive change, to treat them in some way that will eliminate the actual annual inequality. This is done, both for declination and horizontal force, by taking the mean of each twelve consecutive monthly values, and again the mean of each two consecutive values, giving a series of annual or smoothed means, the mean epochs of which differ by one month.

In the forty-third volume of the "Memoirs of the Royal Astronomical Society," Dr. Rudolf Wolf, of Zürich, gives a table of relative solar spot values, found by treating actual monthly numbers (for the purpose of removing accidental irregularities), exactly in the same way in which the monthly magnetic numbers were treated.

The magnetic numbers and Dr. Wolf's sun-spot numbers are thus strictly comparative, and from these numbers curves are drawn which show a remarkable similarity. Not only do the epochs of minimum and maximum accord, but smaller changes are also seen to appear in all three curves.

The epochs of minimum and maximum being tabulated, it is found that, on the average, the mean magnetic epoch follows the sun-spot epoch by 0·27 of a year. By another method of tabulation the difference becomes reduced to 0·10 of a year. Some other interesting details are here added.

The general circumstance that the diurnal ranges of magnetic elements are subject to an eleven-year period, similar to that of sun-spots, being considered to be satisfactorily established, it seemed desirable to ascertain whether the more fitful changes of the phenomena in any way also correspond. In order to make this comparison, the magnetic numbers, instead of being smoothed, as before described, were now cleared only of the *average* annual inequality, and compared with the *actual* monthly sun-spots numbers (not the smoothed numbers as before). Curves are given, founded on these numbers, and they show some very

* Abstract of a Paper presented to the Royal Society "On the Relation between the Diurnal Range of Magnetic Declination and Horizontal Force, as observed at the Royal Observatory, Greenwich, during the years 1841 to 1877, and the Period of Solar Spot Frequency."

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remarkable correspondences between the more rapid sun-spot and magnetic variations, especially between the years 1869 and 1873. It is remarked that the magnetic results appear to be sensibly improved since the instruments were placed (in the year 1864) in an underground apartment in which the diurnal range of temperature is less than 1°.

Further inquiry seems to point to a variation in the annual inequalities of magnetic diurnal range. This question is discussed in some detail, and the numbers and diagrams given appear to show that such variation really exists, the inequalities being increased at the time of a sun-spot maximum, and diminished at the time of a sun-spot minimum.

The following are the general conclusions supposed to be derived from the whole inquiry:

1. That the diurnal ranges of the magnetic elements of declination and horizontal force are subject to a periodical variation, the duration of which is equal to that of the known eleven-year sun-spot period.

2. That the epochs of minimum and maximum of magnetic and sun-spot effect are nearly coincident; the magnetic epochs, on the whole, occurring somewhat later than the corresponding sun-spot epochs. The variations of duration in different periods appear to be similar for both phenomena.

3. That the occasional more sudden outbursts of magnetic and sun-spot energy, extending sometimes over periods of several months, appear to occur nearly simultaneously, and progress collaterally.

4. That it seems probable that the annual inequalities of magnetic diurnal range are subject also to periodical variation, being increased at the time of a sun-spot maximum, when the mean diurnal range is increased, and diminished at the time of a sun-spot minimum, when the mean diurnal range is diminished.

Conclusions Nos. 1, 2, and 3 appear to be sufficiently certain, but the evidence in favour of No. 4 is not so decisive.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

Report of the Directors for the six months ending 30th June, 1879 to be presented at the Fourth Ordinary General Meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, in the city of London, on Friday, the 1st day of August, 1879, at 12 o'clock noon:—With this report the Directors submit the usual statements of account for the half year ending 30th June, 1879, which, with the half year's accounts to the 31st December last, presented at the Ordinary General Meeting on the 21st March last, show the financial result of the second year's working of the Company. For the half year the revenue, after deducting outpayments, amounted to £87,706 3s. 2d.; for the corresponding period of 1878 the amount of revenue, after similar deductions, was £79,852 11s. 5d. The working and other expenses (exclusive of cost of repairs), interest on loan, and income-tax, &c., amounted for the half year to £20,523 5s. 10d., leaving a balance of £67,182 17s. 4d. as the net profit for the half year, making, with £5,273 8s. 4d. brought from the previous half year, a total of £72,456 5s. 8d. In the corresponding half year of 1878 the expenses and payments above mentioned (also exclusive of cost of repairs) amounted to £20,065 17s. 9d. The cost of repairs for the half year, amounting to £8,965 9s. 11d., has been paid for out of, and is charged against, the reserve fund. Three quarterly interim dividends of 1¼ per cent. each, amounting to £45,532 10s., have been declared and paid at the usual times during the financial year; and a final dividend of 5s. per share is now proposed, making with the three interim dividends 5 per cent. for the year, being a total distribution of £60,710. The appropriation of the above balance of £72,456 5s. 8d. on the revenue account is thus shown:—Interim dividend for quarter ending 31st March last, £15,177 10s.; final dividend now proposed, £15,177 10s.; carried to reserve fund, thereby increasing it to £100,000, £34,756 4s. 3d.; written off preliminary and arbitration expenses, £5,000; carried forward to next account, £2,345 1s. 5d. Total, £72,456 5s. 8d. The agreement with the Dominion Telegraph Company of Canada, referred to in the last report, has been completed, and came into operation as from the 1st January, 1879. The particulars of the award in the arbitration between the liquidators of the old Company and Mr. Loeffler were fully stated at the Ordinary General Meeting on the 21st March last. The break in the Company's main cable, which occurred on the 4th January last, was repaired on the 20th March, and the interruption on the 12th February last of the short section was repaired on the 22nd April. Both sections of the cable are in good working order.

RECENT PATENTS.

4011. Arrangement of Telephonic Circuit, *J. H. McClure.—Dated 10th October*, 1878.—(*Not proceeded with.*) 2*d*.

This consists in employing one or more resisting boxes, each having a slider, and so arranged that by moving the slider the resistance of the telephonic circuit can be varied, so that the signals are brought out more distinctly.

4022. Arrangements for Electric Lighting, *J. W. T. Cadett.—Dated 11th October*, 1878.—(*Not proceeded with.*) 4*d*.

This consists in employing resisting mediums between the lamps and the source of electricity.

4016. Electric Lighting, Heating, and Motive Power Apparatus *J. Munro.—Dated 11th October*, 1878.—(*Not proceeded with.*) 4*d*.

This consists of a divider based upon the principle that if the current supplying an electric lamp be a discontinuous or intermittent one whose pulsations occur a sufficient number of times per second the practical effect is the same as if it were a continuous current. A shaft is caused to revolve with great rapidity round the axis, and the near ends of all the separate lamp circuits are caused to centralise themselves round this shaft. The shaft is connected to one pole of the electric source, and a brush contact is so fitted to it as to sweep the ends of the circuits round the shaft. The circuits are insulated from one another. The far ends of the lamp circuits are connected to the other pole of the source.

4031. Softening and Diffusing Electric and other Light, *A. M. Clark.—Dated 11th October*, 1878.—(*A communication.*) 6*d*.

Glass globes are formed with double or two skins, the space between them being filled with powdered glass, glass wool, or wadding, spun glass, calcined mica, silver leaf, or other material of a flocculent nature capable of reflecting, screening, and diffusing light.

4041. Electro-magnetic Engine for Driving Rotary Hair Brushes, *W. North.—Dated 12th October*, 1878.—(*Not proceeded with.*) 2*d*.

The apparatus consists of an electro-magnetic engine composed of an iron spindle carrying a number of electro-magnets wound with insulated copper wire, and thrown into the battery circuit by brass or platinum pins which revolve with an outer frame upon the central spindle, and make contact with the terminals of the electro-magnets.

4528. Telephony, *H. G. Haddan.—Dated 8th November*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d*.

This consists—First, in the combination with a telephone of a condenser. Secondly, in connecting two or more wires of a telegraph line running in the same direction, and using them as a conductor. Thirdly, in grounding the wire of a telephone circuit at one, two, or more intermediate points, and in the insertion in said ground wires of a condenser for the purpose of diminishing the injurious effects of foreign induced currents. Fourthly, in connecting two or more independent galvanic circuits by means of a condenser.

4529. Telephones and Telephonic Call Mechanisms, *H. J. Haddan.—Dated 8th November*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d*.

This consists of one or more permanent magnets which are used in common for the purpose of magnetising the cores of the telephone electro-magnets, and also to magnetise the cores of movable coils or electro-magnets used for the production of induced currents for signalling purposes.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices July 23.	Business Done Week Ending July 23. Highest.	Lowest.
Anglo-American ....ex div.	53¼, 54	54	53⅝
Do. "B" ....ex div.	82¾, 83¼	83¼	82¾
Do. "A"	26¾, 27	27¼	27
Brazilian	6¾, 7¼	6 1-16	6 15-16
Cuba	7¾, 8¼	7 1-16	8
Do. Ten per Cent. Preference	15¾, 16¼	—	—
Direct Spanish	1¾, 2¼	2	1⅞
Do. Ten per Cent. Preference	10¾, 11¼	—	—
Direct United States	10¼, ¾	10⅜	10⅜
Eastern ....ex div.	7 1-16, 3-16	7⅛	7 11-16
Do. Six per Cent. Debenture	105, 108	—	—
Do. Five per Cent. do.	103, 105	104½	104½
Do. Six per Cent. Preference ...x d.	11 13-16, 15-16	11⅞	11⅞
Eastern Extension ....ex div.	7 13-16, 15-16	7⅛	7 11-16
Do. Six per Cent. Debenture	108, 111	—	—
German Union	7¾, 8	—	—
Globe Telegraph and Trust	4¾, 5	5	4 13-16
Do. Six per Cent. Preference....	10 15-16, 11 1-16	11	10⅞
Great Northern	8¼, ½	8⅜	8¼
Indo-European	20¾, 21¼	—	—
Mediterranean Extension	2½, 3	3	3
Do. Eight per Cent. Preference....	9, ½	—	—
Reuter's	9, 10	—	—
Submarine	227, 232	—	—
West India and Panama	1⅜, ⅝	1½	1½
Do. Six per Cent. Preference....	7¾, 8¼	7 15-16	7 15-16
Western and Brazilian	2¾, 3¼	—	—
West. Union Seven per Ct. 1st Mt....	118, 122	—	—
Do. Six per Cent. Sterling	107, 109	—	—

TRAFFIC RECEIPTS FOR JUNE, 1879.

Companies.	June 1879.	June 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company....	—	—	—	—
Cuba Submarine Company....	2,400	3,175	—	775
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	15,000	—	—	—
Eastern Extension Telegraph Company	26,485	23,269	3,216	—
Eastern Telegraph Company	36,635	31,118	5,517	—
Great Northern Telegraph Company	19,618	—	—	—
Submarine Telegraph Company	10,661	10,350	311	—
West Coast of America Telegraph Company.	1,025	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

UNDERGROUND WIRES IN GERMANY.—A subterranean telegraph wire has just been laid down between Hamburg and Bremen, and Oldenburg and Emden, with branch lines to Bremerhaven and Wilhelmshaven.

EDISON'S QUADRUPLEX SYSTEM.—Dr. Cornelius Herz, the concessionaire of this system for Europe, has been invited by the French and Belgian Governments to place at their disposal a complete set of apparatus for quadruplexing the line between Paris and Brussels.

AERIAL LINES IN CYPRUS.—The following gives a detailed statement of the land lines completed by the Eastern Telegraph Company in Cyprus, referred to in our issue of last week :—Larnaca to Nicsia, a distance of twenty-five miles ; Nicsia to Kyrenia, a distance of nineteen miles ; Larnaca to Famagusta, a distance of twenty-four miles; Larnaca to Limassol, a distance of twenty-eight miles ; Limassol to Pappo, a distance of forty miles; giving a total of 136 miles of line.

TELEGRAPH RATES TO AUSTRALIA.—It is said that the efforts made by the Royal Commissioners of the Australian Exhibition to obtain a reduction of telegraphic rates in favour of exhibitors at Melbourne and Sydney have failed of success, solely by reason of the uncompromising opposition of Lord John Manners, who holds "that as the telegrams in question would be sent with the view of facilitating the arrangements of manufacturers and tradesmen who are exhibiting for trade purposes, and because of the pecuniary advantages they are expecting to derive, he can see no reason why the Post Office Department should forego its revenue for their benefit."

MICROPHONIC STUDY.—M. Boudet de Paris has experimented with a microphonic transmitter, in which the carbons, instead of being pressed by a spring, are simply kept in contact by a bit of paper folded like a V. It was so sensitive that, with a single Lechlanché cell, and at a distance of 500 metres (1,640·4 feet), the receiving telephone reproduced the message so that it could be heard in all parts of the hall. By increasing the amplitude of the vibrations he found that they were of two kinds: 1. Large vibrations, or rather undulations, which always occurred in the same order for any given word or vowel. 2. Small vibrations, very short, very numerous, looped upon the larger ones. He thinks that the undulations are due either to the force of the breath which necessarily accompanies the emission of the voice, or to the inertia of the instrument.—*Comptes Rendus.*

BRITISH ASSOCIATION.—The first general meeting will be held on Wednesday, August 20, at eight p.m. precisely, when William Spottiswoode, Esq., M.A., D.C.L., LL.D., Pres. R.S., F.R.A.S., F.R.G.S., will resign the chair, and Professor G. J. Allman, M.D., LL.D., F.R.S. L. and E., M.R.I.A., Pres. L.S., president elect, will assume the presidency, and deliver an address. On Thursday evening, August 21, at 8 p.m., a *soirée*; on Friday evening, August 22, at 8:30 p.m., a discourse by William Crookes, Esq., F.R.S., on "Radiant Matter;" on Monday evening, August 25, at 8:30 p.m., there will be a discourse; on Tuesday evening, August 26, at 8 p.m., a *soirée* ; on Wednesday, August 27, the concluding general meeting will be held at 2:30 p.m. On Saturday evening, August 23, W. E. Ayrton, Esq., will deliver a lecture to the operative classes on "Electricity as a Motive Power." Tickets can be purchased of the local secretaries.

LEASE OF THE DOMINION TELEGRAPH COMPANY'S LINES.—It is reported that the lines of the Dominion Telegraph Company of Canada have been leased to an American company on the following terms:—The American company take up all unissued stock of the Dominion Company (289,000 dols.), at 80 per cent., 140,000 dols. of which is to be applied to pay off floating liabilities, leaving 90,000 dols. to be used in extending the lines, &c. The lessees are to pay for interest on Dominion telegraph bonds 30,000 dols. annually, and at their maturity pay the same off, and pay quarterly in advance five per cent. on the capital of 1,000,000 dols., the first quarter's interest being now in hand. They also pay 2,500 dols. per annum for the maintenance of the company's organisation, such as Board, secretary, &c. The Canadian Board is to be maintained. The lease is for ninety-nine years from the 1st of July, inst., and should the lessees in any way fail to carry out their agreemeent or pay over quarterly dividends, interest on bonds, &c., the Dominion Company, at the expiration of thirty days, are empowered to terminate the lease.

ELECTRIC CONDUCTIVITY. — Several remarkable results have been recently obtained by Herr Kohlrausch in his researches on the electric conductivity of aqueous solutions, and especially on the influence of temperature on the conducting power of liquids, as given in the *Annalen der Physik.* Thus, concentrated soda-lye, which, at a temperature of − 10 deg. conducts badly, acquires, under action of heat, a conducting power which increases regularly and with very great rapidity, so that at + 80 deg. the liquid conducts a hundred times better than at − 10 deg. A solution of bisulphate of potash behaves quite differently; its conducting power increases very slowly with the temperature, up to a temperature of 60 deg., at which there is a maximum. From this point the conductivity remains nearly constant, as the temperature is raised. Studying solutions of sulphate of soda, which are known to present at 33 deg. a remarkable peculiarity, due to the proportion, more or less, of water of crystallisation, Herr Kohlrausch found nothing peculiar in the conducting power. This, it is considered, seems to prove that water of crystallisation does not play any part in the conductivity of liquids for electricity.

THE CASPIAN CABLE.—In our report of the visit of the Delegates to Silvertown, in our issue of June 28th, we mentioned that they saw the manufacture of a cable for the Russian Government intended to be laid across the Caspian. The correspondent of *The Times* at St. Petersburg gives the following information relating to this cable:—Six large masted barges, towed by three steamers, lately arrived in St. Petersburg from Cronstadt heavily laden with the cable destined to be laid between Baku and Krasnovodsk, and orders have been given to hurry it to its destination. The wire, which measures about 147 nautical miles, weighs nearly 62,000 puds, and, including the expenses of transport and sinking, will altogether cost about £62,000 sterling, has been specially manufactured for the Russian Government by the India Rubber and Gutta Percha Telegraph Works Company in London, and has been conveyed to Cronstadt in the

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Great Northern, a vessel specially constructed for laying cables. The little fleet of barges and steamers will proceed by the Empress Maria Canal from the Neva to the Volga, whence it will descend as far as Astrakhan, where the cable will be transshipped into a large steamer and sunk in the Caspian at its narrowest parts between Baku and Krasnovodsk.

PRODUCTION OF ELECTRICITY BY EVAPORATION AND OF EVAPORATION BY ELECTRICITY.—At a time when the electrical world is not startled by new revelations every week, when the societies have their vacation, and generally there exists a dearth of news—when, however, everybody is talking of the abnormal state of the weather, it may be well to refer to some of the theories connecting electrical and atmospheric phenomena. For this purpose we shall in a note or two draw upon Sturgeon's "Annals of Electricity" for information. Sturgeon, writing on this subject in 1842, says:—"We are not certain that Dr. Franklin was the first philosopher who entertained the idea of the electricity in clouds being taken up from the earth in its aqueous vapours; but such was his opinion, however, as early as the year 1749, as is clearly stated in his fifth letter, which is highly probable to be the first time that such an idea received publicity. From the results of many experiments on atmospherical electricity, Franklin was led to suppose that the generality of thunder clouds are negatively electrical with respect to the earth." Hence he says, in his twelfth letter, "For the most part, in thunderstrokes *it is the earth that strikes into the clouds, and not the clouds that strike into the earth.*" And, in order to give an explanation for this negative electric condition of clouds, he proceeds thus:—"I conceive that this globe of earth and water, with its plants, animals, and buildings, have diffused throughout their substance a quantity of the electric fluid, just as much as they can contain, which I call the *natural quantity*. That this natural quantity is not the same in all kinds of common matter under the same dimensions, nor in the same kind of common matter in all circumstances; but a solid foot, for instance, of one kind of common matter, may contain more of the electric fluid than a solid foot of some other kind of common matter; and a pound weight of the same kind of common matter may, when in a rarer state, contain more of the electric fluid than when in a dense state. For the electric fluid being attracted by any portion of common matter, the parts of that fluid (which have among themselves a mutual repulsion) are brought so near to each other by the attraction of the common matter that absorbs them, as that their repulsion is equal to the condensing power of attraction in common matter; and then such portion of common matter will absorb no more. Bodies of different kinds having thus attracted and absorbed what I call their natural quantity, *i.e.*, just as much of the electric fluid as is suited to their circumstances of density, rarity, and power of attracting do not then show any signs of electricity among each other. And if more electric fluid be added to one of these bodies, it does not enter, but spreads on the surface, forming an atmosphere, and then such body shows signs of electricity. I have in a former paper compared common matter to a sponge, and the electric fluid to water; I beg leave once more to make use of the same comparison to illustrate further my meaning in this particular. When a sponge is somewhat condensed by being squeezed between the fingers it will not receive and retain so much water as when in its more loose open state. If *more* squeezed and condensed, some of the water will come out of its inner parts and flow on the surface. If the pressure of the fingers be entirely removed the sponge will not only resume what was lately forced out but attract an additional quantity. As the sponge in its rarer state will *naturally* attract and absorb *more* water, and in its denser state will *naturally* attract and absorb less water, we may call the quantity it attracts and absorbs in either state its *natural* quantity, the state being considered. Now, what the sponge is to water the same is water to the electric fluid. When a portion of water is in its common dense state, it can hold no more electric fluid than it has; if any be added it spreads on the surface. When the same portion of water is rarefied into vapour and forms a cloud, it is then capable of receiving and absorbing a much greater quantity; there is room for each particle to have an electric atmosphere. Thus water in its rarefied state or in the form of a cloud will be in a negative state of electricity; it will have less than its *natural quantity*—that is less than it is naturally capable of attracting and absorbing in that state. Such a cloud, then, coming so near the earth as to be within the striking distance, will receive from the earth a flash of the electric fluid; which flash, to supply a great extent of cloud, must sometimes contain a great quantity of that fluid." Again, our philosopher states:—"Thus thunderclouds are generally in a negative state of electricity compared with the earth, agreeably to most of our experiments; yet, as by one experiment we found a cloud electrised positively, I conjecture that in that case, such cloud, after having received what was, in its rare state, only its *natural quantity*, became compressed by the driving winds, or some other means, so that part of what it had absorbed was forced out, and formed an electric atmosphere around it in its dense state. Hence, it was capable of communicating positive electricity to any rod." The principal object for bringing forward these quotations is to show that, in the opinion of this great philosopher, the aqueous vapour rising from the surface of the earth is *negatively electrical* with respect to the natural electrical condition of the water from which it ascended. There are, however, other topics of high theoretic importance contained in these few paragraphs. One of the great beauties in Franklin's theory is that, under natural circumstances, each peculiar kind of matter is possessed of a *specific quantity* of the electric fluid; an idea parallel to that of Dr. Black respecting the specific heat of bodies, and may eventually perhaps become of parallel practical importance. In support of this part of his theory Dr. Franklin invented a very interesting experiment with a can and chain, now well known amongst electricians. A brass chain of some few yards long was coiled in a silver can, and a certain degree of electric action, measured by an electrometer, was given to this apparatus by a spark from a machine. One end of the chain was now lifted up by a silk thread previously attached to it until most of the chain was out of the can. With this increased surface the electric tension became much lessened, but when the chain was again let down into the can the electric tension increased almost to its original degree. "Thus," says Franklin, "we see that increase of surface makes a body capable of receiving a greater electric atmosphere. But this experiment does not, I own, fully demonstrate my new hypothesis, for the brass and silver still continue in their solid state, and are not rarefied into vapour as the water is in the clouds. Perhaps some future experiment on vapourised water may set this matter in a clearer light. One seemingly material objection arises to the new hypothesis, and it is this: If water, in its rarefied state as a cloud, requires and will absorb more of the electric fluid than when in its dense state as water, why does it not acquire from the earth all it wants at the instant of its leaving the surface, while it is yet near and but just rising in vapour?"

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COMMERCIAL APPLICATIONS OF ELECTROLYSIS.

BY PAGET HIGGS, C.E., LL.D.

(First Paper.)

Electro-plating, gilding, and silvering are very well known processes. Their application is, however, somewhat justly regarded as limited to the artistic trades, and their extension to that rank of commercial respect accorded to operations on a large scale, has received but little literary attention. It is intended, in this series of Papers, to deal with those applications of electrolysis that include the use of a special plant, and are conducted on an extensive scale. In this consideration it will be necessary to revert incidentally to some scientific principles that have not been generally stated, and in doing so, it will be the object of the writer to be as suggestive as possible, without entering on the purely theoretical.

Nicholson and Carlisle were the first to effect, in 1800, the decomposition of water by a series of Volta's cups, and we learn from their statement* that their surprise was great when the constituent gases of the water appeared separately. The occurrence seems to have been beyond their resources for explanation. Cruickshank, some time later, repeated the experiment, and for the first time decomposed several metallic salts.†

Cruickshank attempted to explain the phenomena by the supposition that the principle of galvanism could exist in an oxygenated and deoxygenated condition, and that, as the galvanic current entered the water at the negative pole, it combined with the oxygen, liberating hydrogen. At the positive pole it was supposed to escape or to combine with the water.‡ Fourcroy, Vauquelin, Thenard, Bostock, and others modified this theory, which remained till Sir Humphry Davy, in 1807, asserted that—"The oxygen of a portion of water is attracted by the positive surface at the same time that the other constituent part, the hydrogen, is repelled by it, and the opposite process takes place at the negative surface; and in the middle or neutral point of the circuit, whether there be a series of decompositions and recompositions, or whether the particles from the extreme points only are active, there must be a new combination of the repelled matter." Grotthus§ advanced the theory that polarity, like that of a magnet, was established in the elements of water. Faraday extended this theory, and showed how the molecules of the electrolyte could revolve;|| and his is the explanation at present accepted.

Tribe, to whom is owing the most recent researches¶ in the subject of electrolysis, considers that an electrolyte may be regarded as a dielectric whose molecules are possessed of the power of mutually exchanging their constituents during discharge; and that there is resemblance between magnetic and electrolytic substances in certain points. His experiments demonstrate that an insulated conductor may, by immersion in any part of an electrolyzing fluid, become endowed with the property of doing work exactly similar in kind to that done by two battery electrodes, but that its working power is dependent more or less upon its length, position in the fluid, and conductivity, as well as chemical activity. It is well known that the poles or electrodes of a battery are each charged with electricity opposite in kind, but possessed of similar properties, to the electricity of friction, though much less intense. This being so, were an insulated conductor placed lengthwise, so as to ensure the maximum effect between the electrodes of a battery, the whole being immersed in air, it is certain that, were our instruments sufficiently delicate to detect it, the end facing the positive electrode would be found charged with negative electricity, whilst the other end, facing the negative electrode, would be found charged with positive electricity—that is, the conductor would become endowed with the power of doing work as previously stated. Tribe considers that the two actions just mentioned are parallel phenomena; and if the polarisation of the insulated conductor immersed in air be ascribable to induction, the polarisation of the conductor immersed in an electrolysing fluid may also be attributed to the same cause. The difference between the two phenomena lies in the fact that a high electric tension is necessary to effect the depolarisation of the particles of air by discharge, which, of course, is unaccompanied by decomposition; whereas only a very low electric tension is required to effect the depolarisation of an electrolyte, which, on the contrary, is always accompanied by decomposition. Tribe's experiments further show that a suspended rigid conductor, surrounded by an electrolysing fluid, may transmit the electric power as though it were transparent to that influence, and that the electric influence spreads itself out in the electrolyte in the same way that the magnetic influence does in the magnetic field.

In the course of these Papers it will be seen that the foregoing theoretical principles, based, as they are, upon exact experiment, can be made explanatory of some difficulties besetting the practical electro-metallurgist.

Before proceeding further, it may be better to say that no commercial results have been obtained with the electrolysis of water, up to the present time, partly because of the cost of developing the electric current. It has been proposed, and a company was formed, to electrolyse water (with the Alliance machine), to obtain the gases, and to apply these to the purposes of illumination; but, for obvious reasons, nothing resulted from this experiment, except an impetus given to the construction of magneto machines.

The subject of water dismissed, there remains only for practical purposes, the consideration of the electrolysis of the solutions of salts, whether of the metals or of the earths, and, as of far greater immediate import, the subject of metallic solutions first presents itself.

Ere the metallic solution can be electrolysed it is necessary to select a source of current. Currents may be obtained either from

a galvanic battery (or heat battery, upon Jablochkoff's principle),
a magneto or dynamo-electric machine, or
a thermopile.

Most of the forms of galvanic batteries are too well known to need description here; that which may be the best form is determined wholly by the conditions of electromotive force and quantity of current required. Although galvanic batteries are still very largely used, they have been, so far as regards zinc-consuming batteries, superseded by magneto machines, on the ground of expense. Iron-consuming batteries have not, as independent current sources, met with success; but in an extension of what is known as the single-bath process, there is great promise of wide application in the reduction of copper, not for ordinary galvanoplastic operations, but in the precipitation tanks of the copper works.

In the ordinary process of precipitating copper, the lixiviation liquor is run into tanks, covering a large area and containing iron generally in the form of pig iron or of scrap. The iron, immediately it comes into contact with the liquor, becomes coated with a layer of spongy metallic copper. This layer, although spongy, prevents, in a considerable degree, the further reduction of metallic copper, and, as percolation of the cupreous liquor through the spongy mass is slow, the consumption of the iron and deposit of the copper are retarded. The deposit is uncertain, for the reason that the first formation of the deposit occurs in those places most rapidly where the iron is least protected by rust and dirt. With concentrated solutions of copper, containing a high percentage of metal, the iron becomes coated with a metallic layer so impervious to the solution as to render effectual protection to the iron, which remains until the shell of copper is broken, and is the occasion of loss of effective iron surface in the tanks, including loss of time and expenditure of labour.

To meet this difficulty, it has been proposed and tried to introduce the iron in such form as would give maximum surface with minimum bulk—that is, as sheet or scrap-sheet. But this device, although ingenious, failed in consequence of an indirect practical difficulty. The iron has to be transported generally for long distances, and as particular care would increase the cost by increasing the labour, it has every facility for becoming coated with rust, if not completely eaten away with oxidation, so that what was sheet iron or scrap-sheet arrives at the tanks containing a high percentage of rust, for which carriage has had to be paid. The cost of the iron is so much increased by this loss as to give practically considerable advantages to the use of pig.

N. S. Keith, of New York, has brought into use a method intended to obviate these disadvantages, and effect considerable economy in the consumption of iron. It consists in constituting with the iron a positive electrical element, the negative plate being immersed in the cupreous solution. The iron is placed in a porous vessel, and this vessel is immersed in the cupreous solution. In the cupreous solution is also placed a copper plate which is metallically and electrically connected to the iron in the porous vessel. The arrangement thus forms a single galvanic depositing cell. Copper is deposited on the copper plate as the iron in the porous vessel is dissolved, and the porous vessel being, in the first instance, filled with dilute acid, the iron is completely dissolved without at any time coming into contact with the cupreous solution. For several electro-chemical reasons, the copper thus deposited is much purer than that deposited directly upon the iron.

* Nicholson's Journal, O.S., Vol. iv., p. 183.
† Ibid, p. 189.
‡ Nicholson's Journal, N.S., Vol. iii., p. 9.
§ "Ann. de Chimie," Vol. lviii., p. 65.
|| Tyndall's Lecture on Faraday, Proceedings Royal Institution, Vol. v., p. 218.
¶ Proceedings Royal Society, 1876, p. 309.

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Thus deposited the copper is still spongy, for reason that the electromotive force generated by the relation of the iron to the copper is much greater than is needed to effect the deposition of this metal from the very acid solutions generally used. The writer suggested that this surplus electromotive or chemical decomposing power might be utilised by connecting the iron-containing cells, not directly to the depositing sheet, but interposing in this part of the circuit another decomposing cell, either for depositing copper from the solution or preferably for refining the already-deposited copper by electrolysis. Experiments carried out on a very extensive scale have shown great economy resulting from this method, as by its use nearly pure copper can be obtained in ingots without any smelting process. The method will be presently submitted to the reader more in detail.

ON THE SENSITIVE STATE OF ELECTRICAL DISCHARGES THROUGH RAREFIED GASES.*

BY WILLIAM SPOTTISWOODE, P.R.S., and S. FLETCHER MOULTON, late Fellow of Christ's College, Cambridge.

It has frequently been remarked that the luminous column produced by electric discharges in vacuum tubes sometimes displays great sensitiveness on the approach of the finger, or other conductor to the tube. This is notably the case when with an induction coil a very rapid break is used, or when with any constant source of electricity an air-spark is interposed in the circuit leading to the tube. The striking character of the phenomena, and the opportunity which they showed for affecting the discharge from the outside during its passage, led the authors of this paper to consider that a special examination of this sensitive state would be desirable.

All the circumstances under which sensitiveness is produced appear to agree in requiring, first, that there should be a rapid intermittence in the current leading to the tube; and secondly, that the individual intermittent discharges should be small in quantity and extremely brief, if not instantaneous, in duration. Both these requirements are fulfilled by the methods used in the present investigation, viz., a Holtz machine with a suitable air-spark between the machine and the tube, and a small coil with a rapid break.

If a conductor be made to approach a tube conveying a sensitive discharge, due to an air-spark in the positive branch of the circuit, a series of effects is produced, of which the feeblest and the strongest are the most pronounced. The transition from one to the other is so rapid that the intermediate phases may be easily overlooked. In the first case, the luminous column is repelled by the conductor; in the second it is broken into two parts which stretch out in two tongues towards the point on the tube (P) nearest the conductor, while a negative halo appears between them.

That these effects are due to the inductive action of the conductor, or more particularly to re-distributions of electricity in it, co-periodic with the air-spark, and not to any permanent charge, is shown by the following experiments. A non-conductor, whether charged or not, is without effect. The effect of a conductor increases with its size or capacity, and with its proximity to the tube, until the fullest effect (viz., that given by an earth connection) is produced. That the effects are not due to electro-dynamic, or to magnetic action, is shown by the fact that a coil of wire produces the same result, whether the ends be joined or not. The effects of an iron core and helix with open ends are often comparable with, and sometimes equal to, those when the ends, being connected with a battery, the whole becomes an electro-magnet. The effect upon the interior is, in fact, due to the relief given by the conductor to the electric tension on the outer surface of the tube and the space around it, caused by the ndividual discharges.

Instead, however, of connecting a point (P) on the tube with a large conductor or with earth, we may connect it with one or other terminal of the tube. And a further study of the subject shows that all the phenomena due to action from without may be produced by means of one or other of these connexions. Connexion with the non-air-spark terminal gives the relief effects described above; connexion with the air-spark terminal gives another set of effects. Of these the feeblest has the appearance of attraction, while the strongest shows an abrupt termination of the positive column in the neighbourhood of the point (P), followed by a negative halo, and then by a recommencement of the positive column in the direction of the negative terminal. Each of these sectional discharges is in fact independent and complete in itself, and they are due to impulses of positive electricity thrown into the tube from the air-spark. At the positive terminal these impulses are thrown directly in; at the points of connexion they are due to induction, *ab extra*. The negative part of what was originally neutral meets the positive column, and satisfies it as it arrives, while the positive leaps forward to meet the negative due from the negative terminal.

The effects above described need not be confined to a single patch or ring of conducting material placed upon the tube; but they may be produced many times over in the same tube by a series of rings arranged at suitable distances. By this means the column may be broken into a series of sections, all terminating with well-defined configurations towards the negative end, and having greater or less length, according to the position of the rings. In the paper itself, arguments are there brought forward showing that these sectional discharges represent striæ not merely in their appearance, but also in their function and structure. But the discussion could hardly be produced within the limits of an abstract.

Returning from the digression about striæ, the authors next give evidence, derived mainly from the revolving mirror, and from the discharges of a partially charged Leyden jar, for the following conclusion: That the passage of the discharge occupies a time sufficiently short in comparison with the interval between the discharges to prevent any interference between successive pulses. Certain experiments are then described which indicate that the discharge is effected, under ordinary circumstances, by the passage through the tube from the air-spark terminal of free electricity, of the same name as the electricity at that terminal. In the case of an induction coil, where the air-spark must be considered as existing at both terminals, there is evidence of a *neutral zone*, where the sensitiveness disappears. The position of this zone may be altered by damping the impulses at either terminal; or it may be abolished by connecting one terminal with earth. The impulses may even be so distributed as to divide electrically a single tube into three sections, the two extremes presenting visible discharges, with a dark section between them.

Looking at all these phenomena from an opposite point of view, we may, by means of the relief effects, determine the terminal from which a discharge proceeds, and the distance to which it reaches without provoking a response from the other. And through these considerations, together with others detailed in the paper, the authors are led to the conclusion that the discharges at the two terminals of a tube are in the main independent, and that they are each determined primarily by the conditions at their own terminal, and only in a secondary degree by those at the opposite terminal.

In illustration of this view, an account is then given of the production of unipolar, positive, or negative discharges in a tube. In such cases, the discharge being insufficient of itself to pass through the tube, returns by the way by which it entered.

This closes a series of experiments, the result of which is that the discharges from the two terminals can be made of equal intensity, or of any required degree of inequality; or the discharge can be made to issue from one terminal only, the other acting only receptively; or it can be made to return into its own terminal, while the other takes no part in the discharge; or, finally, the two terminals can be made to pour out independent discharges of the same name, each of which returns to its own terminal.

Having traced the relation between the two parts of the discharge, and having found means for controlling their range and influence, the authors were led to enquire whether there be any experimental evidence of the state of the tube during the occurrence of the discharge. Some experiments with two pieces of tinfoil of unequal size placed near the ends of the tube and metallically connected, and others with a strip of tinfoil placed along the tube, all gave effects showing that the discharge cannot be simultaneous throughout the tube. The phenomena appear to require for their interpretation that, in front of the pulse coming from the (positive) air-spark terminal, there is, during the interval between the pulses, a rising negative potential. This is entirely swept out by the pulse as it advances along the tube; after which the process is repeated. The condition of things behind the pulse is more difficult to determine; but an experiment with the telephone gives reason to think that parts of the tube nearer to the non-air-spark end are in a condition to demand relief before those nearer to the air-spark terminal have ceased to require it. And on this account the discharge may, perhaps, be more nearly represented by a lazy tongs than by a bullet.

How far the results obtained from the sensitive state are applicable to ordinary discharges is a question which cannot yet be definitively answered. But the marked similarities in the phenomena, and the predisposing circumstances of striation or non-

* Abstract of a Paper presented to the Royal Society.

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striation, as well as in the terminal peculiarities of the two kinds of discharge, point strongly to the conclusions that all vacuum discharges are disruptive; and that sensitive differ from non-sensitive discharges mainly in the scale of the discontinuity due to the disruptiveness, causing a difference between the two classes of phenomena analogous to that between impulsive and continuous forces in dynamics.

THE INTERNATIONAL TELEGRAPH CONFERENCE.

BANQUET IN EDINBURGH.

On Saturday, 26th July, the members of the International Telegraphic Conference, were entertained by the Lord Provost, Magistrates, and Town Council of Edinburgh to a cake and wine banquet in the Council Chambers. The Lord Provost presided. A large and brilliant assembly were invited to meet the Delegates. The members of the Conference present were:— Dr. Brunner von Wattenwyl, Councillor of the Ministry of Commerce J. R., Austria; M. J. Vinchent, Director-General of Posts and Telegraphs, Belgium; M. le Commander D'Amico, Director-General of Telegraphs, Italy; General C. de Lüders, Privy Councillor, Director-General of Telegraphs, Russia; Mr. C. H. B. Patey, Assistant Secretary, G.P.O., London; M. le Comte Victor Wimpffen, Inspector-General of Telegraphs, Austria; M. F. Kara, and M. E. Granfeld, Secretary, Austria; M. Koller de Granzow, Councillor of the Ministry of Commerce, Hungary; M. Gibbs, Chief Inspector of Telgraphs, Belgium, and M. Gibbs, jun.; Captain H. Honcke, Director of Telegraphs, Denmark; M. J. Richard, Engineer-Director of Telegraphs, France; M. E. Eschbæcher, Chief of Section to the Minister of Posts and Telegraphs, France; M. J. le Camus, Receiver of Telegraphs, France; M. le Chevalier Berliri, Inspector of Telegraphs, Italy; M. Yoshikawa Akimasa, Director-General of Telegraphs, Japan; M. S. Kirayama, Secretary of Telegraphs, Japan; M. Munchiro Nakano, Japan; M. Nielsen, Director-in-Chief of Telegraphs, Norway; M. Bugge, Inspector of Telegraphs, Norway; M. de Rego, Director-General of Telegraphs, Portugal; M. Robescu, Director-General of Telegraphs, Roumania; M. P. Salmonovitch, Chief of Section of the Department of Telegraphs, Councillor of State, Russia; M. Pissaravsky; M. Staring, Director-in-Chief of Telegraphs, Netherlands; M. Curchod, Director, and M. de St. Martial, Secretary, Bureau International; M. Salmond, Assistant Secretary of the Department of Posts and Telegraphs, ditto; M. Radoycovitch, Chief of Section of Posts and Telegraphs, Servia; M. Nordlander, Director-General of Telegraphs, Sweden; M. Akerlund, Secretary of the Administration of Telegraphs, ditto; M. A. Frey, Central Director of Telegraphs, Switzerland; Etienne Musurus Bey, Councillor of the Ottoman Embassy at London, Turkey; Guildani Effendi, General Secretary of the Administration of Telegraphs Turkey: Messrs. E. Graves, engineer-in-chief; W. H. Preece, electrician; F. E. Baines, Surveyor-General of Telegraphs; H. C. Fischer, Controller Central Office; P. Benton, Assistant Controller, Accountants' Department; W. H. Winter, Controller of Stores, General Post Office, London; Mr. J. Pender, M.P., Eastern Telegraph Company; Sir C. Bright, Major Wood, Mr. Lewis Wells, M. Carl Siemens, M. Borring, Mr. E. Bright, M. Ansell, and M. C. Gerhardi, representatives of telegraph companies.

The LORD PROVOST, in proposing "The Queen," said he was sure there was no one present, from whatever quarter of the globe he might come, but would join with him in wishing Her Most Gracious Majesty Queen Victoria long life and every blessing.

The LORD PROVOST then gave "The Prince and Princess of Wales, and the other Members of the Royal Family."

The LORD PROVOST next proposed "The Crowned Heads and Presidents of States."

Mr. ROBINOW (German Consul), in acknowledging the toast, said he could only hope with his lordship that there might now be perfect peace, and that it would be lasting.

The LORD PROVOST then proposed "The Distinguished Representative Gentlemen now present" [applause]. He said: We are honoured with the presence to-day of the Delegates of the International Telegraph Conference, who began their official meetings in London last month. Almost all, or all, European nations, as well as trans-European, are represented, and all the important telegraph companies over the world. I am only sorry that the short time during which the strangers are to be in Edinburgh prevents us from showing such attention as we could have wished, but such as it is, we give it with a most cordial welcome [applause].

M. le Commandeur D'AMICO, Director-General of Telegraphs in Italy, in returning thanks in French, said: I have, on behalf of my colleagues, to express our most cordial thanks to the Lord Provost for the reception which he has given us to-day, and for the kind words which he has employed in speaking of the labours of the Telegraphic Conference [applause]. We all love Scotland very much. At a very early period of our lives we made ourselves acquainted with Scotland. We travelled through the Scottish Lowlands and the Scottish Highlands, admiring the picturesque mountains, the lovely lakes, the old castles, so rich in historical remembrance, and the noble towns, so justly proud of their names [applause]. Our guide in such wondrous travelling was the immortal Walter Scott [applause]. Our sympathy once aroused, we studied Scotland with interest, and learned how brave were Scotchmen, from the time of their resistance to the Romans to the days of Ashantee [laughter and applause] and how much they have contributed to the progress of the civilisation of mankind through literature, philosophy, and science [applause]. The names of Robertson, Dugald Stewart, Hume, Adam Smith, Watt, and Macaulay are a few names which, amongst an illustrious band, are now in our remembrance [applause]. In regard to the subject of telegraphy, we have to pay that homage which is so justly due to the name of Sir William Thomson [applause]. We have been desirous to see more fully this country, which for so long a time had been the object of our thoughts. To-day we have received during our travels ample confirmation of our previous impressions. We have been greatly delighted with what we have seen, and we now beg to express our admiration, and also our cordial thanks, to the Lord Provost, magistrates, and Town Council, who have provided this splendid banquet [applause].

Treasurer HARRISON proposed "Prosperity to International Telegraphy." He said that in an assembly composed to so large an extent of mercantile men, he need not say what advantage they derived from the harmonious working of the various States and telegraph companies throughout the world in carrying on their business [applause]. The facilities thereby given to them were enormous; and he was glad to say, on the responsibility of many merchants, that the international working of the telegraph was very perfect indeed [applause]. After referring to agitation for the taking over of the telegraph by the Government, he said: The result of it was, that, with the sanction of the two great parties in the State, the bill was carried through both Houses of Parliament; and he thought it due to the postal and telegraph departments of our own country as well as other departments that he should ask the company to drink "Prosperity to International Telegraphy" [applause].

Mr. C. H. B. PATEY, Assistant Secretary, General Post Office, London, proposed the toast of "The Edinburgh Chamber of Commerce." After speaking of some of the work of the Conference, he proceeded—In regard to the tariff with Europe, that also would be found to be lowered in some instances very considerably, more especially to the four countries with which England had its greatest intercourse—France, Belgium, Holland, and Germany. In regard to these there would be a decrease, but that was not to be wondered at when he told them that of the messages to foreign countries 80 per cent. were to those he had named. In connection with the word code a change was brought about by the Conference at St. Petersburg which preceded that of London. The only difference now was that a slight alteration had been made in the number of languages allowed for code messages; but in that he thought no difficulty would be found to arise. They had agreed to the excision of the Turkish language, and now there were left eight languages, and consider- that no less than 78 per cent of the messages sent to the East were in English words, and the remainder divided among the other languages of Europe, 3 per cent. being only in the Turkish language, that language had been cut out; because, moreover, they were unable to ascertain in England whether they were Turkish words or not. By the excision of that language they would therefore say that very little harm had been done to the mercantile community.

Mr. NIELSEN, Director-in-Chief of Telegraphs, Norway, proposed "The Lord Provost and the City of Edinburgh" [applause]. He said he had to return thanks on behalf of the members of the Conference present for the cordial reception that had been given to them. In visiting Edinburgh, the capital of Scotland, many events that took place long ago arose in their minds. It had passed through the fire, as it were, and became what it was by the labour and ability of Scotchmen. They must all admire the capital of a kingdom which had shone so greatly in the promotion of the sciences [applause]. He had to return thanks very cordially for the hearty welcome they had received [applause].

The LORD PROVOST said that, on behalf of the Magistrates and Town Council of the city of Edinburgh, he begged to return to their friends who had visited them their sincere thanks for the honour which they had conferred upon the Corporation.

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THE ELECTRICIAN.

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THE ILLUMINATING POWER OF THE ELECTRIC ARC.

Two or three papers, relative to the electric light, and derived from French and American sources, which have recently appeared in our columns furnish data and results which appear to be of such exceptional importance as to call for special notice. One of them, written by M. Hyppolyte Fontaine, the author of the most popular work on "Electric Lighting," contains a statement which will attract the attention of all who are interested in this question. With a continuous-current Gramme machine, working at a velocity of 1,000 revolutions per minute, a mean intensity of light equivalent to 285 Carcel burners has been obtained by the expenditure of one horse-power; the arc being just one centimètre in length. If we take the Carcel burner as equivalent to nine of our standard sperm candles, we have here an illuminating power of 2.565 standard candles per h.p. Nor was this result obtained by the concentration of great power in a single light; for the total horse-power expended in working the dynamo-electric machine was less than $4\frac{1}{2}$. Moreover it is put forward not as a *maximum* but rather as a maximum *practical* result. Making every due allowance in the direction indicated by M. Frank Géraldy in the article we translate for our present issue, it seems certain that this result is indicative of progress, and merits our attention. We may best judge of it, probably, by comparing it with the result as calculated upon previous data. According to those given by M. Fontaine himself, at the end of the ninth chapter of his "Eclairage à l'Electricité," the production of one Carcel burner per kilogrammetre, or about 76 per h.-p. was, some two years ago, considered indicative of great progress made. This duty corresponds to an illuminating power of 680 standard candles per h.-p. If we take Mr. FitzGerald's formulæ, printed on p. 7 of our last volume, and based upon the results obtained, with the same machine, by the Committee of the Franklin Institute, the light thrown in all directions horizontally would, supposing the resistance of the arc to be half the total resistance, be less than 400 candles. If, as M. Fontaine states, the mean luminous intensity in every direction may be taken as twice the horizontal intensity, this would correspond to a mean luminous intensity of less than 800 candles. Lastly, according to Mr. W. H. Preece (p. 166 of the same volume) the light per horse-power should not be greater than that of 758 candles. But it would appear that even more than three times this duty has now been obtained from a Gramme machine by the expenditure of one horse-power.

The value of the tables given by M. Fontaine would, undoubtedly, have been greater if certain electrical data had been added to the dynamical and photometric determinations. We should have been interested to know, for instance, what was the variation of the current when the velocity of the machine was gradually augmented from 700 to 1,000 revolutions per minute, and when the distance between the carbons was decreased from 5 to 1 millimetres. The increased duty obtained by increasing the velocity and the distance between the carbon points might have been clearly accounted for if the variations in the current elements had been noted; and, even without such information, one would be inclined to surmise, if not to conclude, that the relative resistance of the coils of wire in the machine was, in most of the experiments, too high. So far as they go, however, the data supplied by this authority will be appreciated by all who take an interest in electric lighting. By those who are winning their experience, such hints as that for adjusting the distance between the carbons to suit any given conditions, viz:—ascertain the distance at which the light becomes extinguished, and adjust to half this distance, will be very gratefully received. And the fact that the quantity of light obtained when a cable 100 metres long was used for conducting the current became halved only when the length of cable had been increased to 2,000 metres, will have the effect of reassuring those who have got hold of the idea that the light varies inversely as the square of the length of cable, or thereabout.

If the paper by M. Fontaine is specially interesting from a practical point of view, that by Professors Thomson and Houston is even more so from a theoretical standpoint. The first of the three laws stated by them is not only of fundamental importance in relation to the theory of the electric

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arc; it also reconciles views which are apparently diverse and even contradictory by bringing practical results into complete accord with theory. We are not aware that this law has ever previously been enunciated, although it has repeatedly been pointed out that the resistance of the arc varies when that of the remaining portion of the circuit is varied. No doubt many will feel that they have tacitly recognised the existence of the law, and as if, in fact, they must all along have known of it; for it is no exaggeration to say that it has been staring us in the face for years. It might have been inferred from the fact that the convection of carbon between the electrodes increases with the current, and it constitutes the only condition under which the statement that the heat and light in the arc vary simply as the current can be reconciled with the law of Joule. Still we cannot find that anyone has hitherto gone so far as to state the law *that the conductivity of arcs of equal length varies simply as the currents traversing them.* It remains to be ascertained whether this law admits of any possible exception.

The second law, which we think should be limited (and which is probably intended to be limited) to a given arc, or to arcs of equal length, may be deduced from, and is explained by, the first. This second law has been previously enunciated; it was stated in the plainest terms by Mr. W. H. Preece, in his lecture on the Electric Light, at the United Service Institute;* the lecturer observing that "the light in the arc varies directly as the current, and not as the square of the current as is generally assumed;" whilst, "in the case of an incandescent wire, the light increases as the square of the current." But no attempt was made to explain the apparent anomaly in the two cases; otherwise it is most probable that the first law would then have been elucidated. For it is to be observed that expressions such as those given in Mr. FitzGerald's formula previously referred to ($\lambda = \text{h.-p.} \times \frac{r}{R} = I^2 r$) are necessarily and generally true, so far as light may be taken to vary as energy evolved, since they are merely expressions of the well-verified law of Joule; whilst the law that the quantity of heat and light varies simply as the current (or that $\lambda = I$) can be true only when resistance varies inversely as current (or when $r = \frac{1}{I}$, and consequently $I_2\, r = I$). Thus the slightest attempt to reconcile with Joule's law the statement that the heat and light in the arc vary simply as the current must almost inevitably have led to the discovery which is expressed by the equation $r = \frac{1}{I}$.

The third law formulated by Professors Thomson and Houston is, like the second, altogether dependent upon and satisfactorily explained by the first. In fact, this third law may be regarded as the second stated in a more accurate form; for there are several circumstances which, as pointed out by the authors of the communication, render the second law merely approximative; whereas the third law is absolute if the first be unconditionally accepted. The explanation we have given of the second law applies strictly to the third; the total energy being $I^2 r = I$.

The theoretical considerations put forward by the authors of the paper are worthy of very attentive perusal; and we shall look forward with interest to the results of the further experiments which are being conducted by the same skilful and accomplished investigators.

* Vide *The Electrician*, Vol. II., p. 167.

CORRESPONDENCE.

ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although I am aware that some, and probably a considerable proportion, of those who belong to the modern mathematical school of electricians now regard the term *force*, applied to the value which is generally expressed as E in the equation for Ohm's law, or to difference of potentials, as being simply a misnomer, I may fairly consider the letter of Dr. Lodge in your last issue to represent the views which have been, and still are, prevalent amongst the disciples of this school.

As I intend, if possible, to devote some little time and labour to the refutation of statements and assumptions made in this communication from Dr. Lodge, I need not here occupy much space in expressing my thorough disagreement in regard to these views. I should at once point out, however, that your correspondent appears to have fallen into a complete misconception of the real point at issue; it is natural, therefore, that he should fail to perceive its importance. The question is not as to whether there be a force which may correctly be termed "electromotive force;" but as to its measurement. Dr. Lodge and his school measure it as E; the old school of electrical physicists measured it as $\sqrt{E}$. I maintain that the former are wrong, that the latter were right. In regard to the importance of the question at issue, I freely admit (and insist) that, if I am mistaken in this conclusion, I have no business to be teaching electricity and writing in your columns as an electrician—rather should I go to school again, work up my mathematics, and endeavour to obtain a little knowledge of the fundamental laws of the science, whilst I have any capacity for study left. And, *mutatis mutandis, res remanet*—excepting the additional mathematics. The school of electricians to which Dr. Lodge belongs will have to realise the fact that what they have to defend themselves against is not merely a charge of verbal and venial inaccuracy but the imputation of having fallen into a blunder so grave that it necessarily vitiates the whole of their system, so inexcusable (in view of the work done by their predecessors) that no one having any claim to the title of physicist should have failed to avoid it. Their case is analogous to that of a man who might refer to four yards or four pounds as a double length or weight, to nine yards or nine pounds as threefold quantities, not by reason of any inability to find or to use a yard measure or a pound mass, but merely because the articles to be measured or weighed happened to be usually presented to him in parcels of 1, 4, 9, 16 yards or pounds, and associated with something else varying in arithmetical progression. They have in fact utterly failed to notice or to understand Dame Electra's way of doing business. They have not observed that, when we require her to condense our supplies of electricity into unit capacity, she sends us parcels in which energy and force are both as the square of the electrical quantity; whereas, if we give her a separate vessel for each unit of electricity, then electricity, energy and force vary in the same ratio. And yet, to show how inexcusable is the blunder, she makes them *pay* for all their supplies, not in proportion to the electrical quantities or to the artificial value they misname "force," but in proportion to the work, and also to the real measurable force, associated with these quantities.

Dr. Lodge states that there is "something which has no action on ordinary matter, but produces electric currents, *i.e.*, causes electricity to move," and he says that "a very reasonable name for this something is electromotive force." I know nothing of any force, or any function of a force, answering to this description; but, if such a force exist, it must be altogether distinct from that which produces the effects of electrical attraction and repulsion. Here we have already two forces; and it is easy to show that, according to Dr. Lodge, "potential" must be a force. Then there is "tension," which must constitute a fourth "force." How many more electrical forces there may be in Dr. Lodge's philosophy I cannot tell; but I know of one electrical force only, to which all electrical phenomena are due.

According to my view, which is that of the old electrical physicists, the fundamental law of electrical action, on which any correct electrical theory must necessarily be based, is expressed by the relation $Q = \frac{\sqrt{F}}{R}$. The question has been raised:—Do electricians of the modern mathematical school merely ignore this law, or are they simply ignorant of it? Now, Dr. Lodge, referring to E.M.F., says:—"It is not ordinary force, but neither is it the square root of it, or anything of the sort, any more than a quantity of electricity is the square root of a force multiplied by a length." Will Dr. Lodge kindly tell me whether he did not

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here mean to write "divided by a length," and whether this "length" corresponds to a "resistance?" If so, I shall know how to answer the above question; if not, I do not comprehend what he means.

DESMOND G. FITZGERALD.

A SUGGESTION FOR SHORTENING TELEGRAPHIC MESSAGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following plan of shortening telegraphic messages seems to the writer to be worth publicity, although he is assured by a very high authority that the suggestion is of no practical value.

The method consists in putting the message through a preliminary process before it reaches the hands of the telegraphic operator. An entire language is constructed with the sole view of shortness in telegraphic transmission. The number of permutations of 26 letters, not more than four together, and where each letter may be repeated up to four times, is 475,254. Each of these arrangements may be called a *telegraphic word*. Let them be set down in the order of their brevity in transmission. For example, what may be called *one signal words* are t, e; *two signal words*, i, a, n, m, tt, te, et, ee; *three signal words*, s, u, w, tm, tet, &c.; and so on. Having thus tabulated the permutations, we assign to each (or to as many as may be required) an *English word or phrase*, after a careful investigation by the method of averages of the most frequently used English words and phrases. This task done, dictionaries must be prepared for the purpose of translating English into telegraphic language, and *vice versâ*. With their help the messages, before sending, would be translated and be re-translated at the other end. The translation would, on an average, require for transmission *much less than half* the number of signals necessary for the original. Indeed, it is obvious that a language constructed with the sole aim of shortness for telegraphic purposes must be much briefer in that respect than any existing tongue. The word "language" is, however, rather a misnomer, as the majority of its words would be unpronounceable. The chief objections which have been raised to the scheme are that the translation and re-translation would entail much labour, and that it would be necessary to send the signals of the abbreviated message slowly and distinctly, and to repeat the whole of it back again. So far as regards submarine telegraphy, to which the process seems most applicable, it may be replied that:

1. The translation would not require skilled labour; it would be done with practice very rapidly, and it would not *occupy the cables*. Hence, the cost of this operation would not be of much moment, if the actual time of transmission was considerably reduced.

3. In the case of mechanical transmitters and receivers, is it a fact that unusual slowness or a repetition of the message would be necessary? The correctness of the translation, and re-translation being assured, would not one, sending in the ordinary way, suffice?

Codes for special purposes have been long in use, and that fact seems to point to the feasibility of a wider application of similar principles. So far as the writer is aware, the suggestion of constructing an entire language as above sketched is new; but it is idle to discuss the originality of a plan the practical value of which is not admitted. Yet, though the method may be one of the vast host which are strong only in theory on paper, it may possibly suggest to some of your readers the creation of a much more doughty knight than a mere paper one. And, if only on that ground, it appears to deserve to be placed on record.—Yours, &c.,

EDWYN ANTHONY.

PRACTICAL DIVISIBILITY OF THE ELECTRIC LIGHT.*

[We now give this Paper complete because a good deal of interest has been shown in the subject since we published the abstract.—ED. *E*.]

We wish to communicate to this academy our new system of the economical division and distribution of light in general, for its application to all purposes of lighting, both public and private; being a practical solution to that great desideratum, the

DIVISIBILITY OF THE ELECTRIC LIGHT.

In the last few years the *electric light* has asserted its own prominent place before the world, and its great advantages begin to be generally acknowledged; the methods to produce it have attained the necessary perfection to be practical to a large extent, as we find it now successfully used in the lighting of large spaces, such as theatres, factories, railroad depôts, stores, lighthouses, government buildings, and similar places.

The superiority of the electric light over any other is of various kinds. Examined by the spectroscope it is found to be nearly equal to sunlight; it does not alter the natural colour of objects, is soft, white, and brilliant; whereas *gaslight* is of a dirty yellowish colour, tiresome to the eye, and alters the natural colour of objects.

Then electric light irradiates almost no heat; whereas the heat emitted by gas flames is universally recognised as uncomfortable and very unhealthy.

Moreover, the electric light requires no air to sustain it, whereas gaslight, like all others produced by combustion in the open air, vitiates or poisons the atmosphere, because it consumes the oxygen thereof, and emits instead the foul products of combustion, among which are sulphuric acid and sulphurous acid; and it is well proven that an ordinary gas-burner vitiates as much air as four grown persons do.

Again, electric light is odourless, whilst the peculiar fetid odour of gas and gaslight is uncomfortable and unhealthy.

Electric light is not liable to explosions as the gaslight is, nor does it require the expensive, disagreeable, and prolonged repairs so often recurring in the gas system.

Finally, electric light is, in fact, far cheaper than gaslight whenever produced and consumed in large quantities. If we were to build a complete gas factory for each dwelling or building in a city the cost of gaslight would be enormous; yet such has been the case with the trials of the electric light, which have given the wrong idea of its excessive cost produced for a single building. Electric light has been compared with the price of gas when produced for a whole city, and even thus in some cases it has proved to be the cheapest.

To show which is in general the relative cost price of electric light and gaslight, we will substitute the price of every item composing the cost of light, in each system, for an amount of coal of an approximately equal price, and we will obtain the value of light irrespectively of the local prices of the items. Some dynamo-electric machines produce light at the rate of 6,000 candles per horse-power spent. One horse-power consumes from two to seven pounds of coal per hour—to make allowances, let us call it six pounds; the incidental expenses and the repairs of the steam engine we will put at one-quarter the value of fuel, which is excessive, one and a half pounds; the attendance of the steam engine will certainly not cost more than one-half the value of fuel, three pounds; the expense for carbon points in the latest trials has been only one-half of the value of fuel, three pounds; the incidental expenses and repairs for the electric machines, we will put like those of the steam engine, one and a half pounds; and the attendance of the electric apparatus will certainly cost less than that of the steam engine; but we will call it like that, three pounds, in all 18 pounds; add 10 per cent. for contingencies, and the result is that 6,000 candles for one hour of electric light will cost as much as twenty pounds of coal.

Now, in gas making, one ton of coal gives as an average 9,000 cubic feet of gas; the cost of lime and labour is not less than one-third the cost of coal, or, in our case, 750 pounds, which, added to the ton, make 3,000 pounds of coal. Supposing, now, that the residue of gas making is merchantable to the extent of 40 per cent. of the above, which is a very favourable case, we obtain as the cost of 9,000 feet of gas equal to the cost of 1,800 pounds of coal. Hence, one pound of coal is equivalent in cost to five feet of gas, or an ordinary burner of 15 candles in one hour; hence, 400 pounds of coal represent the cost price of 6,000 candles of gaslight in one hour; and, consequently,

$$\frac{\text{Cost price of gaslight}}{\text{Cost price of electric light}} = \frac{400}{20} = \frac{20}{1};$$

or the mere production of the electric light, irrespective of distribution, is not more than the one-twentieth part of the cost of gaslight. The practical application of the electric light in several countries shows that this is near the truth. The most striking instance of this fact is the recent trial made in Albert Hall, in London. They used four of the smallest Siemens machines, and four of the Jablochkoff candles at the orchestra. Let it be observed that these circumstances were very unfavourable. In the first place, they used small-sized machinery of a capacity of 2,000 candles per horse-power, whereas other larger machines give up to 6,000 candles per horse-power; in the second place the light was needed only three hours, and fully one extra hour was spent to put up steam and down the fires; therefore the fuel was wasted 30 per cent. above the time needed; in the third place the attendants' wages were paid as a full day's work for only three hours' use. Yet the actual expense of every item, *plus* a liberal allowance for wear and tear, amounted, for

* A paper, by E. J. Molera and J. C. Cebrian, read before the California Academy of Sciences, April 21st, 1879.

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that night, to $12.50, having the lighting proved a complete and satisfactory success. In former occasions, the gas bill for the same building and for the same length of time had been (at the low price of London gas) $36.50; very nearly three times as much as the former figure. If we take San Francisco prices for every item, the above prices would stand thus: Cost of electric light, $27.50; cost of gaslight, $126; nearly five times as much. If the light had been needed six hours instead of three, the figures would be as follow: Cost of electric light, $39.00; cost of gaslight, $252, or six and a half times as much. We will add this single item: that the cost of installation of the electric light for that building was $4,000, which is much less than the price of gas-pipes and gas-fixtures of the same building.

THE DIFFICULTY.

But although having so many great advantages, the great difficulty with the electric light has been how to handle it, how to apply it in practice, after the light is produced. All the methods or systems of electric lighting heretofore proposed may be divided into two classes: 1st class. Those that use a few number of strong lights. 2nd class. Those that use a large number of small lights. The strong lights are the cheapest, as demonstrated by practice. While a generator of electricity having a capacity of 4,000 candles, requires an expenditure of one horse-power for every 1,500 candles, a generator having a capacity of 30,000 or 40,000 candles, will produce light at the rate of over 3,000 candles per horse-power; and in case of a higher capacity the production attains a rate of 6,000 candles per horse-power, as said before. But a powerful light of 60,000 candles for instance cannot be properly used in general; it is too powerful for a small place, and even for a very large place; a number of smaller lights regularly distributed will give a much more efficient illumination. The use, therefore, of strong lights is very limited in practice.

Consequently the attention has been turned to the second class of illumination; and, having failed in building a machine that would produce a small electric light, at the same cheap rate of a powerful machine, all the endeavours have been directed to the economical subdivision of a powerful electric current into small currents that would produce small lights. All such attempts have been failures, because according to known electrical laws, corroborated by practice, whenever an electric current is subdivided, the light-giving power of each secondary current is smaller than inversely proportional to the square of the number of the sub-currents. For instance, a light of 40,000 candle-power divided into 100 lights, will give 100 lights of four candle-power each, or 400 candles in all; this is a loss of 99 per cent.; if the number of smaller lights increases fivefold, the loss will amount to 998 per thousand, and so on.

This evidently places this second class of electric lighting altogether out of any practical application.

DIVISION BY OPTICAL CONTRIVANCES.

In order to avoid dealing with that electrical law, we were led to try the division of the light itself, leaving the electric current untouched. The result has been our system, in which we only use *optical* means or contrivances, and it can, therefore, be applied to the electric light, as well as to any other kind of light.

We take the most powerful source of light obtainable, and place it in a closed chamber or box, called the *chamber of light*. Every wall or face of this box is a condensing lens or a combination of lenses, such that will shape the light into a beam of parallel rays; some of the walls or faces may be only reflectors, throwing the light upon some of the condensing lenses. For instance, the wall or face holding the stand of the light will be a reflector.

In this way, we reduce our source of light to several beams of parallel rays, without the smallest stray ray of light being lost.

When light is not condensed, the intensity thereof is inversely proportional to the square of the distance from the light, because light is then diffused equally in all directions around its focus. But when light is condensed, as above said, its intensity along the straight line of the beam remains unaltered, except a small loss by diffusion, which for a short distance is small. Therefore our chamber of light permits to send light from one place to another without appreciable loss.

If we intercept one of these beams of parallel rays of light by a reflector, the light will be bent or reflected according to the position of the reflector; and it may thus be sent into any desired direction, horizontal, vertical, or any way inclined. When the reflector intersects the whole beam of light, this latter one will be bent totally; if only one fraction of the sectional area of said beam is intersected, then the corresponding fractional part of the beam will be bent, leaving the other fraction thereof to follow its former direction. Therefore, if one of said beams of light is intersected at different points of its length, by different reflectors, intersecting different fractional parts of its section, said beam will be divided into a great number of secondary beams, going into any desired direction, and if these secondary beams are treated in the same way, the main beam can be divided, subdivided, conveyed, and distributed to any number of distant places. If we enclose the main beam in a tube or pipe, and every secondary beam in smaller tubes, branching out from the larger one adjoining it, and we keep the above said reflectors at the elbows and intersections, or T pieces, formed by all these tubes, we will obtain a net or system of pipes or tubes similar to those used in the distribution of gas and water.

Such is our system; in front of every side or face of our *chamber of light*, we place a box or pipe enclosing the main beams of light; these pipes are laid along the streets; at every side street a smaller pipe will branch out from the main one; at their junction we will place a reflector which will divert into the side street the desired percentage of light. And thus we can provide every street of a city with one or more pipes carrying a known amount of light. Then, from said street pipes, service pipes will be run into every lamp-post and every building, and at the intersection of the latter pipes with the street main we will insert proper reflectors, the size of which will determine the amount of light supplied by every service pipe. In the same way that at present the gas burners of all the rooms in a house are in direct successive communication with the gas meter or service pipe, for said house, through a net of pipes laid along ceilings and walls; similarly in our system, a net of properly branched out pipes will put in communication every room of a building with the above mentioned service pipe; only that we will place at every junction, occurring in said net of pipes, a proper reflector, which will determine the amount of light carried by the corresponding pipe. Thus, the light may come into the rooms through the ceiling or through the walls, every room having as many outlets of light as desired. But the light will enter in a beam of parallel rays; therefore, in order to properly shape it for use, we will place at every outlet of light a *diffusing lens*, called a *secondary lens*, which will send the light around in any predetermined shape; thus completing the system of division and distribution of light from a single station to any or all the rooms in a city, and with any desired intensity.

Our system allows to control the light in three ways, to wit: 1st, in its intensity; 2nd, in its shape; 3rd, in its chemical and physical properties.

1ST.—CONTROL OF THE INTENSITY OF LIGHT.

If the reflectors in the pipes are stationary, the amount of light in every pipe will be constant, as long as the intensity of the original focus of light remains unaltered; but if said reflectors are made movable, we can control the supply of every pipe, or every set of pipes, at will, by making said reflectors to intersect a larger or a smaller portion of the next preceding beam of light. Therefore, the last reflector for every outlet of light will do the same service as the gas keys now in use; because its sliding motion will allow the light to enter the room in more or less quantity, down to a mere glimmer, if so wished. Another way to control the intensity of the light in a room, is by means of a contracting or sliding diaphragm or screen, placed near the outlet of light, and provided with any controlling mechanism which will allow the whole ray of light, or only a part thereof to enter the room.

One of the great advantages of our system consists in the interdependent control of light of several rooms. To illustrate it, suppose we have three adjoining rooms with a common supply pipe; suppose the reflector of the first room intersects the lower third of said pipe, the reflector of the second room intersects the two lower thirds of the same pipe, and the reflector of the third room embraces the whole section of the same pipe. In that way, every room will receive one-third of the whole light in said pipe. Now, if we slide the first reflector inside of the two lower thirds of the supply pipe, the intensity of light in the first room will vary at the expense of the second room, and *vice versâ*; if we slide said first reflector into the upper third of the supply pipe, the intensity of the first room will vary at the expense of the other two rooms. Likewise, if we leave the first reflector as at the beginning, and then we slidethe second reflector inside of the two upper thirds of the pipe, the intensity of the second room will vary at the expense of the third room and *vice versâ*, leaving that of the first room unaltered. Finally, if we slide the first and second reflectors in perfectly parallel uniform motion, the intensity of the second room will be constant, and that of the first room will vary at the expense of the third room, and *vice versâ*. What we have said of three rooms, may as well be said of any number of rooms, and also of any number of floors in a building. Therefore, our reflectors allow to shift the light from one room into any other in the same building, in whole or in part, with perfect accuracy and simplicity.

This introduces an element of great economy for household

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purposes. Were it not for this circumstance, every house lighted by our system would have to get a constant supply of light for every room and place to be lighted, whether the places were in constant use or not; and as not all the rooms in a house are used at the same time, such an arrangement would be very wasteful, which is the case with all the other systems of electric lighting yet proposed.

2ND.—CONTROL OF THE SHAPE OF LIGHT.

The secondary lenses above-mentioned will control by their shape and position the shape of the light. If the light comes from the ceiling and a diffusing lens is used, it will send down a cone of light extending all over the floor, for instance: if the curvature of the lens were different, said cone might be made wider, so as to illuminate the walls as high as desired, and the ceiling too; or it might be made narrower and the light be concentrated upon a work table, a sewing machine, a writing desk, &c. At present a room may be lighted with one or two gas burners of 15 candle-power each; and yet they often are insufficient to read or write by; either you have to get with chair and desk near the burner, or you have to use shades, reflectors, drop lights, or some inferior kind of light upon your table. But, in our system, by properly swinging the secondary lens, we can throw the cone of light to any desired place in the room where it is needed; and, by this means, eight or ten candle-power in our system will, in most cases, be more serviceable than fifteen or thirty candle-power is with the present system of light, or in any of the electrical systems heretofore proposed. By the same means the cone of light may be thrown away from any place where it is not needed, as from a sick bedstead for instance.

This circumstance also increases the range of utility or adaptability of light to many especial purposes without expense or trouble. Because, by using a proper lens, we can project the whole amount of light into a point, if so needed, thus affording the microscopist, for instance, a powerful aid in his work. The physican also can perform medical operations and body examinations at night with comfort and perfection. The engraver, the draughtsman, the watchmaker, in fine, all workers of delicate work can extend their operations at night with comfort and economy; whilst by any other system of lighting the amount of uncondensed light needed for such purposes would be too great to be economical; and if condensed by an additional artificial means, it would add extra expense and would never be so comfortable as in our system.

The best plan will be to furnish every house with a set of two to three different inter-changeable lenses for general purposes; and every individual may add the special lenses adapted to his work, his tastes, or his needs.

3RD.—CONTROL OF THE PHYSICAL AND CHEMICAL PROPERTIES OF LIGHT.

We have only to intercept the beam or beams of light before they reach the secondary lenses with shades of different colours, and of appropriated substances or media, and we will modify the properties of light at will, with ease and economy. This is invaluable for the treatment of ophthalmic diseases at home and in hospitals; it is of great service to photography, where lights of different colours and of different actinic power are needed; it will aid many other industries in analogous ways; it will be a most powerful and fitting aid to theatres, where scenic effects of all kinds are needed.

COMPARISON WITH OTHER ELECTRICAL SYSTEMS.

Let us compare now our system with the others. The first class of electric lighting has a very restricted, practical limitation both in its applications and its cost. It is very seldom that a very strong light can be utilised; being, therefore, necessary to produce electric lights of a not very large power, which increases more and more the expenses; and even then it cannot be used in small spaces. On the other hand, all the systems of the second class of electric lighting, in which the electric current is divided, have two practical limitations. As the waste or loss of electricity increases with the number of small lights, it is necessary to use a weak original current in order to decrease the number of said lights; hence great expense of production. And if the production be made cheap by making the original current very powerful, then the number of subdivisions increasing, the loss and expense grow out of proportion. In both cases those methods are inapplicable.

Whereas our method, allowing the subdivision of light into any number of smaller lights and of any desired intensity, with a small loss, that is independent of the number of lights, affords the opportunity to produce electric light in very large quantities, larger in fact than ever before attempted; it will, therefore, be much cheaper, and no other system can claim this advantage. This will make our method extremely cheap; and besides it can be utilised or applied to all kinds of uses, from the highest requirements of modern industry to the most humble of household purposes.

The loss in our system is so small because it is independent of the number of the secondary lights produced; it is only due to the reflection of light, which can be reduced practically to only 8 per cent. for each reflection, using totally refracting prisms as reflectors. And as in a city there will not be required more than six reflections or changes of direction, the total loss will never exceed in practice 50 per cent. of the original light, no matter in how many small lights the light is subdivided. But in the second class of electrical systems, the total loss far exceeds 999 per cent, per thousand; and when the number of secondary lights increases, the total amount of light reaching destination is soon less than 1-100,000th of the original light. This single fact shows the immense superiority of our system upon any other yet proposed.

But this is not its only advantage.

When the current of electricity is divided, the secondary currents must be independent of each other; otherwise, when one of the lamps has to be extinguished, or its intensity varied, all the other currents and lights would also be altered; to obviate this, every secondary circuit has to be made of a constant resistance, which means that whether a lamp is lighted or not, or whether its intensity is varied, the secondary circuit corresponding to it always spends a constant amount of electric current. This introduces an element of great wastefulness. Moreover, the currents or circuits of each room in a house being independent of each other, they are wasted away, whether the room is in use or not. All of which is avoided in our system by the shifting of light from place to place, as explained before. To put an instance, let us suppose a house having fifteen places to be lighted, rooms and halls. Some rooms need sometimes six or eight burners, some four, some less: as an average, such house will have thirty or thirty-five burners, although not in constant use. By any of the other systems of electric lighting that house needs a constant supply of electricity enough for said thirty or thirty-five burners; whilst in our system a constant supply of twelve or fifteen burners will suffice for all purposes, because the light can always be shifted in any amount to the room where needed. This item alone gives to our system a saving of about 50 per cent. upon all the others.

Another consideration is that the systems with subdivided currents require every lamp to be connected to the general circuit by two conductors. The length of the circuit would soon attain hundreds of miles for a city; it has been estimated that the conductors needed to supply the city of Berlin with electric light by such systems would cost some $60,000,000. And all such expenses are avoided by our system.

Again, the number of electric lamps or regulators needed in such systems is excessive; which will greatly increase the expenses. The lamps, besides, require a great deal of attention and great expenditure of carbon points; and as they are delicate mechanisms, they are not fit to be used by people in general, they are very liable to get out of order, producing expenses for repairs, and often depriving the consumers of their light; therefore they are expensive and uncomfortable. All of which is also avoided by our system.

Finally, we will observe that the electric light always produces a whistling noise, and that its intensely focal heat acts chemically in the air, giving out small quantities of nitrous acid and nitric acid, which are very poisonous. Both defects are unavoidable in any system of electric lighting except in ours. Ours also is the only system where the focus of light is kept away from the places where used, which affords the opportunity of saving to the consumers the trouble attending to any machinery or electric regulator.

COMPARISON WITH GAS LIGHTING.

Comparing now our system with gas lighting, we must observe that its use will present no difficulties to the consumer; the motions of the prisms and the secondary lenses will be as easy as the turning of a gas-key; no matches will be needed; no fear that a burner was carelessly left open; and no machinery required for that purpose about any building. Our system must certainly have all the advantages of the electric light upon gaslight, already granted and mentioned before. The only one in dispute was about the *cost*, which our system lowers to an unprecedented degree.

To prove that it is so, we will examine: 1st. The outlay needed to put up a system of lighting; 2nd. The running expenses of the enterprise; and 3rd. The waste or loss of the system.

1ST.—CAPITAL NEEDED.

The pipes used in our system are not subject to any especial pressure, may be of any material, and need no gas-tight joints; therefore their cost when laid must be smaller than that of gas pipes. The price of the prisms or reflectors will certainly cost less than the labour of making tight joints.

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As for the works or machinery to produce electric light, their cost is exceedingly below that required for gas works, where very large spaces are needed, and costly, huge buildings and machinery required.

One important item is the outlay made by the consumers in order to receive the light in their buildings. Instead of the costly net of gas pipes made gas tight, our system requires simply wooden or tin boxes, instead of the expensive gas burners, brackets, chandeliers, &c., we need only a set of prisms and lens, of a low price, that will never wear out, and never need repairs on account of leakage. The advantages of our system in this respect are self-evident.

2ND.—RUNNING EXPENSES.

As for the running expenses, we will remark that the capacity of the largest dynamo-electric machines in operation has attained the rate of 6,000 candles per horse-power spent. It has also been noticed in the different patterns of dynamo-electric machines made, that when the light-giving power increases three times or over, the horse-power required only increases twice. It is therefore likely that a machine of a 100 horse-power will have a capacity of over 15,000 candles per horse-power. Such and still more advantageous machines will be used in our system.

When electric light is produced at the rate of 6,000 candles per horse-power, its mere production costs about one-twentieth the cost of gaslight. When produced at a rate twice as large, its cost must be less than one-fortieth the cost of gas; because the increase in the production of electric light does not require a proportional increase in labour or wages. The same number of attendants will take care of an electric lamp and a chamber of light giving forth 1,000,000 or 2,000,000 candles; and a 200 horse-power steam engine does not require twice the number of attendants than an engine of 100 horse-power. Whereas, in gas making, as the gas produced is proportional to the number of retorts in operation, an increase in the production of gas must require a proportional increase in labour or wages.*

3RD.—WASTE.

The wastes of gas making are many, but we will only mention those occurring from the gas holder to the gas burners. The waste or leakages through the street pipes has been computed at from 5 per cent. to 20 per cent.—we will put it at only 10 per cent. The leakages occurring in the gas pipes and fixtures of buildings are from 20 per cent. to 40 per cent.—let us estimate them at only 20 per cent. The waste on account of defective gas burners is the most import—it reaches sometimes to 86 per cent. of the gas consumed; in London, where great care is exercised in that respect, it has been computed by gas engineers that fully 25 per cent. is lost on that account—we will put the average at only 40 per cent. The total of these wastes amounts to over 56 per cent. of the gas manufactured. Whereas in our system the wastes are only 8 per cent. for each reflection, and the total can never exceed in practice 50 per cent.—less than those of gas distribution.

The facts therefore about our system are:—

1st. The outlay of consumers for lighting fixtures is smaller for our system than for the gas system.

2d. The capital invested for lighting works in our system is smaller than that required for gas works.

3d. The production of electric light by our system will be a very small fraction of the cost of producing gaslight.

4th. The loss or waste of distributing light by our system will be smaller than that occurring in the distribution of gas.

The legitimate consequence, therefore, is that our optical system affords the means of producing and distributing electric light in a city, at a mere fraction of the actual price of gaslight.

In conclusion, it will be readily seen that our system can be adapted to all purposes of lighting. It may as well furnish electric light to a *whole city* from an original station, as to a *single building*, or set of buildings.

It can be extended in a most fitting manner to the lighting of *mines*, without fear of explosions, without increasing the temperature or contaminating the air; and the light can always be easily shifted to the precise place where the work is being done.

In *ships* the use of our system will be invaluable, as it allows not only to have powerful mast lights, but, on account of the minute distribution of light, every department in the ship may be lighted without fear of conflagration.

For all kinds of industries and commercial places where danger of fire is to be apprehended, such as *warehouses*, *store rooms*, *powder works* and *magazines*, *chemical factories*, and the like, our system is *the only one* that can be used, as it allows to have all the light needed without the possibility of starting any fire.

Our system will also allow to use light in places where formerly it was unthought of—as, for instance, in *railroad tunnels*.

Finally, for all large institutions like colleges, libraries, hospitals and asylums, factories, barracks, prisons, and other public establishments, our system, besides totally preventing fires, has the great advantage that the light can never be meddled with by the inmates of the institution, but it is under the direct control of only one supervising officer.

(TO BE CONTINUED).

* As an interesting fact we will notice that there are in San Francisco about 13,000 buildings supplied with gas; the average cost of their gas pipes and gas fixtures is at a low estimate 1,000 dols. per building; making in all 13,000,000 dols., which is more than twice the capital needed to build new gas works to supply the whole city. The repairs of those fixtures, the taxes and the interest of that money represent over 2,000,000 dols. yearly; whereas the total amount of the yearly gas bills paid to the San Francisco Gas Company is only 1,500,000 dols. Therefore the community in San Francisco pays on account of the gas fixtures nearly 140 per cent. of what it pays for gas bills. That makes the price of gas over 7 dols. per thousand instead of 3 dols.

THE INTERNATIONAL TELEGRAPH CONFERENCE.

BANQUET AT MANCHESTER.

The Delegates to the International Telegraph Conference visited, on the 22nd July, Manchester, and were entertained at a complimentary banquet by the President of the Manchester Chamber of Commerce, Mr. Benjamin Armitage. The banquet took place in the state apartments at the Town Hall, which had been lent for the occasion by the Mayor. The Delegates present were:—M. le Dr. Brunner de Wattenwyl, M. F. Kard, and M. E. Granfeld, Austria; M. Koller de Granzow, Hungary; M. Vinchent and M. Gibbs, Belgium; M. Höncke, Denmark; M. J. Richard, M. E. Eschbaecher, and M. J. le Camus, France; Mr. C. H. B. Patey and Mr. P. Benton, Great Britain; M. le Commandeur E. D'Amico and Le Chevalier Berliri, Italy; M. Yoshikawa Akimasa, M. S. Kirayama, and M. Munehiro Nakano, Japan; M. Neilsen and M. Bugge, Norway; M. Staring, Netherlands; M. do Rego, Portugal; M. Robescu, Roumania; M. de Lüders, M. Salmonovitch, M. Pissarewsky, Russia; M. Radoycovitch, Servia; M. Nordlander and M. Akerlund, Sweden; M. A. Frey, Switzerland; Etienne Musurus Bey, and Guildani Effendi, Turkey; M. Curchod, M. de St. Martial, and M. Salmond, Bureau International; M. F. de Otin, Spain; Mr. Lewis Wells, Mr. E. Graves, Mr. W. H. Winter, Mr. W. H. Preece, Mr. W. Shuter, Mr. J. Pender, M.P.; Sir Jas. Anderson, Mr. H. Rawson, Mr. Gibbs, jun.; Mr. C. E. Gerhardi, Mr. A. C. Borring, Major Wood, Sir C. Bright, Mr. F. E. Bains, and Mr. W. Stearns, London.

The following gentlemen had been invited to meet the members of the Conference:—The Mayor of Manchester (Mr. C. S. Grundy), Sir Joseph Heron, Mr. W. H. Talbot, the Mayor of Salford, Mr. C. Moorhouse, the Bishop of Salford, Mr. John Slagg, Mr. Malcolm Ross, Mr. Thomas Cooke, Mr. G. H. Gaddum, Mr. C. P. Henderson, jun., Mr. Henry Lee, Mr. Benjamin Carver, Mr. George Lord, Mr. John Mitchell, Mr. Samuel Ogden, Mr. J. C. Zigomala, Mr. James Jardine, Mr. William Mather, Mr. Richard Peacock, Mr. Robert Leake, Mr. W. von Knoop, Mr. Edmund Ashworth, Mr. Richard Johnson, Mr. J. Thewlis Johnson, Mr. Thomas Browning, Mr. O. O. Walker, M.P.; Mr. Henry Dunckley, Mr. H. S. Straus, Mr. Peter Allen, Mr. Charles Bowker, Mr. Alderman Heywood, Mr. C. E. Schwann, Mr. Samuel Armitage, Mr. E. Liebert, Mr. Atho. Joannides, Mr. William Carter, Mr. T. R. Wilkinson, Colonel Shaw, Mr. Edmund Schwabe, Mr. Abraham Haworth, Mr. William Armitage, Mr. L. T. Edminson, Mr. J. Kendrick Pyne, Mr. Wright Turner, Mr. J. A. Hunter, Mr. Fredk. Schuster, Mr. R. Wedemeyer, Mr. Chas. S. Armitage, and Mr. John E. Armitage.

After the toasts of "The Queen" and "The Prince and Princess of Wales" had been honoured,

The CHAIRMAN proposed "The Sovereigns and Presidents of foreign nations," and welcomed the Delegates to Manchester. He trusted that the wires which connected us with every part of the world might serve to bind the nations together in friendship and peace [cheers].

M. le Commandeur D'AMICO responded.

Mr. JOHN SLAGG proposed "Success to the International Telegraph Conference, and health to the Delegates." He said they were told that the power of the Telegraphic Conference amounted to a monopoly, if not to a despotism, for they had telegraphic undertakings entirely in their own hands. They must hope that the Conference would deal with a gentle hand with the telegraphic affairs of that town [hear, hear]. It had been alleged that this extension of the telegraph all over the

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world had not been an unmixed benefit to commerce. It had worked great changes in trade; but he thought they had been in the direction of good. Telegraphic communication had tended immensely to enlarge the area over which the benefits of commerce extended. It had tended to the obliteration of huge monopolies; and it had also been a beneficial influence in facilitating diplomatic intercourse between the nations.

General LUDERS (Russia) responded in French. He remarked that the various nations whom they represented had been discussing some very difficult telegraphic questions of late. Amongst these was the subject of payment for messages. There might be a diversity of opinion about the new rule adopted on this point by the Conference, but he believed the public would be satisfied. The public wanted cheap messages delivered with great speed, and he thought the discussions of the Conference would promote the attainment of those ends [cheers].

Mr. O. O. WALKER, M.P., proposed "The manufactures and commerce of Lancashire.

Mr. HENRY LEE responded.

Mr. JOHN PENDER, M.P., proposed "The Corporations of Manchester and Salford," to which the Mayor of Manchester responded.

Mr. C. H. B. PATEY proposed "The Manchester Chamber of Commerce," and gave an account of the labours of the Conference. He said they had come to the conclusion that a word rate should be introduced, and he hoped that in the course of the next year or two that rate would be in operation for the European telegraphs. The differential rate between London and the country would be done away with, and next year there would be only one rate to every part of the United Kingdom or the world. He thought they had been able to hit upon a tariff which would continue to pay dividends, and still give satisfaction to the public. It would be found that a great reduction had been made in all the rates. With regard to European code messages, scarcely any alteration had been made. In order to give the public the free use of the code language the Conference had decided that eight languages should be employed, namely—English, French, German, Italian, Spanish, Portuguese, Dutch, and Latin. Another alteration had been made which he also thought would be for the benefit of merchants. Heretofore they had been permitted to send five figures as one word, and some difficulties had arisen in connection with this. The Conference had decided that the extra payment for figure telegrams should be altogether abolished, but that, on the other hand, the number of figures allowed to count as one word should be reduced to three.

MR. GEO. LORD responded.

The Bishop of SALFORD proposed "The health of the President," and the toast having been honoured and responded to, the proceedings terminated.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).

The sixth ordinary general meeting of the above Company was held on Thursday, July 31, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. John Pender, M.P., the chairman of the Company.

Mr. WILLIAM PAYTON, the secretary, read the advertisement convening the meeting, and the minutes of the last meeting.

The report was taken as read.

The CHAIRMAN, in moving the adoption, said that the report set out what had been done in the way of exchanges during the past year. They had secured more Eastern Extension Company's shares and a few Submarine Cable Trust certificates, and they did not call for any special remarks. There was one item of difference in the second page of the report, as to the statement of stocks and shares held by the Company, as compared with what they held last year. In their last balance-sheet for 1878 they had a debit item—a loan of £26,000, which had been incurred by the purchase of Direct Company's shares, and to clear off the loan they had to issue their own shares. They accordingly issued 1,500 preference and 1,500 ordinary shares, at the combined price of 77¼ per cent., which realised £23,175, leaving a debit or discount on the ordinary shares of £6,825. That discount must go to the cost of what they bought or exchanged for, and accordingly their accountants had placed the amount to the debit of Direct Company's shares, which were the same as held last year, but they had now the £6,825 added, so that the item now stood 9,945 shares, costing £113,233 9s., instead of 9,945 shares, costing £106,408 9s., as appeared last year. That explained that item. They could not issue more preference shares than they did ordinary shares; and this made them cautious and anxious to exchange in the cheapest way, because any discount on the ordinary shares must be added to the cost of what they exchanged for. The position of the Company, however, was now clear; the loan had disappeared, and their condition was consequently better by being free from all debt. One other item required explanation—that was the interest in suspense—£1,796 9s. 11d. on the credit side of the balance sheet. When the Direct Company was reconstituted there was an accrued account of revenue applicable for dividend on the old Direct shares, and the liquidators of the old company would be able to make a return to the shareholders, but until they knew how much the return would be they would keep the amount in suspense. He hoped that they would get a sufficient return from the liquidators to wipe out the account. A glance at their investments showed that the past year had been satisfactory, having resulted in an additional ½ per cent. to the ordinary shareholders, after paying 6 per cent. to the preference shares. The only other point he need refer to was the increase in their general expenditure as compared with last year, resulting from an increase of £170 in their rent. The balance was mainly an increase of postage through an increase in the number of the shareholders. They paid quarterly dividends, costing about £200 a year in stamps and postage alone. They exercised every economy, but they could not avoid expenses of the kind he had referred to. He had been rather particular in giving them an explanation even in regard to the very smallest items. They were a trust company, and as a trust company it was their business to work it on the most economical principles possible. Although a trust company, as they were aware, the Company was the largest shareholder in the most important submarine telegraph companies existing, and consequently they had a duty to perform towards their shareholders, who entrusted to them this important trust, in seeing that those different companies should be managed in a way that would secure to this Company fair and reasonable dividends. He had spoken to them as to the past. With regard to the future, as they were aware, the Company was largely interested in the Eastern Company, which had been doing during the last year some very important work. A great deal had been done in the Levant, a good deal in the Mediterranean, and they had also become interested in the Black Sea. The Eastern Company, too, in connection with the Telegraph Construction Company, had also interested itself to a very great degree in carrying out the submarine cable to the Cape. The Cape traffic must materially benefit the Eastern Company, and therefore the Globe Company, he hoped, through a better improving state of things. The Eastern Extension Company in the same way had had their cable duplicated to Australia. That would give not only greater facilities for extending the traffic, but would secure a more certain return on the existing traffic. Two cables were better than one, and the interruptions had sometimes been very considerable, telling seriously on the dividends. The duplication of the Australian cable was being done under a guarantee from the Australian Colonies, or some portion of them, who thus showed how they appreciated telegraphy. They regarded one cable as good, but as it was likely to break they had determined to make it as permanent as they could, and they had together subscribed £32,000 a-year towards the laying of a second cable. The next time he addressed them he believed, and hoped, that the cable would be in good working order, and telling favourably on the dividends. Another system the Company was largely interested in was the Brazilian Submarine Telegraph Company, which had done fairly well since it had been established; but they (the Globe) thought it might do better. There was a section of telegraphy along the coast which had not been so fortunate—probably circumstances had been beyond the control of the directors. At all events, he believed that it was now in the hands of parties who were likely to make more of it than had hitherto been done, and consequently he thought that they might safely look for some improvement there; and if there was benefit to the Brazilian Company it would also tend to improve the Globe's position. He had now, he hoped, showed them something of the bright side of the question, but the brightest side often had a shadow passing over it. As they were aware, there was now in course of construction a cable for a French company to compete with the existing Atlantic traffic. That cable had sprung out of a combination which had a good deal to do with the laying of the Direct Atlantic Cable. He would say very little about it, because they must look to the results by and bye. All he could say was that he anticipated for that cable very much the same result which attended the same parties' efforts in establishing the Direct Company—that he believed it would fall into one or other of the Atlantic Company's hands at half price. He thought that when any company established like that on an unsound basis, established at a time when telegraph property was in a very depreciated state, to say the least of it, they could only think that it was done more for the benefit of the contractors than for the general public, or for any particular body of shareholders. Without saying too much, he would only say this—that he hoped that the same result might attend this unsound principle of promoting a submarine telegraph that had attended it heretofore. The Globe Company had its mission. Its mission was exercised in rescuing the Direct Company from a system of management which benefited neither the public nor the shareholders. He was proud to say that it was now benefiting both, and he thought any one who looked to the results of the working of the Company for the last two years would be satisfied that submarine telegraphy, as a property, had been improved under that management. He concluded by moving the adoption of the report and accounts, and the dividend therein recommended on the preference and ordinary shares for the year ending the 18th July.

Sir DANIEL GOOCH, Bart., M.P., having formally seconded the motion,

A discussion ensued, in which Messrs. Griffiths, Veares, Newton, and other gentlemen took part.

The CHAIRMAN, in the course of his reply, said that he believed that during a time of war the telegraphs, instead of being materially injured, would only be injured in sections. As a whole, however, he believed that telegraphs would be benefited. After referring to the importance of telegraphs for national as well as commercial purposes, he alluded again to the improvement in the property of the Eastern Extension Company by the duplication of cable to Australia. As to reducing the tariffs, merchants all along had had an advantage over the companies, and if there had been no coding system introduced, the companies would have been paying now 30 per cent.; but with only one word a page might be filled. He believed in low tariffs, but there was a limit in submarine telegraph companies. After speaking of the importance of telegraph conferences in bringing about a perfect understanding between the Delegates and the representatives of the companies, he put the motion for the adoption of the report, &c., and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Sir DANIEL GOOCH, the Marquis of Tweeddale and the Right Hon. W. N. Massey, M.P., were re-elected directors; and the retiring auditors were also re-elected.

A vote of thanks to the chairman and directors brought the proceedings to a close.

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NOTES.

The Lord Mayor and the Legion of Honour.—*La France* announces that the Lord Mayor of London has been decorated with the cross of the Legion of Honour, in recognition of the reception of the French members of the International Telegraph Conference and of the Literary Congress lately held in London.

Heraud's Battery.—In this couple, mercurous chloride or calomel is employed as the depolarising agent. The electrolyte is a solution of ammonium chloride, to which one-tenth of its volume of ammonia solution has been added, with a view to prevent the formation of zinc oxychloride. A zinc positive element is suspended in the solution, and the negative element is a carbon plate enclosed with the depolarising salt in a canvas bag.

Electric Railways.—Application has just been made to the police authorities of Berlin for permission to construct a system of tramways in the city upon which electricity will be used for motive power. The inventor, Mr. Westpfahl, has had considerable experience in the construction of rail and tramways, and intends, if the Berlin experiment succeeds, to apply the invention in all the larger towns in Germany. We have ready for publication a description of the system of Siemens and Halske, which we hope to find room for in our next issue.

Simple Electric Lamp. By E. Stöhrer, Jun.—The author seeks to avoid the expensive mechanism of the Duboscq, Serrin, and Siemens lamps, all of which are designed for powerful currents. A sheet-iron float is placed within a vertical tube filled with glycerine, and this tube constitutes the core of an electro-magnet, which is included in the circuit. The float bears at its upper end one of the carbon points, and at its lower extremity is continued by a metal rod dipping into mercury, contained in the lower part of the tube, to establish electrical circuit. The float is weighted until electromagnetic attraction is sufficient to overcome the flotative power; by this means the upward pressure of the lower carbon electrode may be made very small, and the voltaic arc and light established with weak currents. The lamp is stated to be successful.—*Annalen der Physik und Chemie,* 1879, p. 459.

Fires.—The telegraph wire as a fire risk has, perhaps, not received (says an American contemporary) the attention it is entitled to. During a thunderstorm which began at Council Bluffs, Iowa, soon after 11 o'clock night of June 10, the freight office and ware rooms building of the Chicago, Burlington, and Quincy Railroad Company was burned to the ground, though most of the contents were saved. It was supposed that the fire was caused by a heavy charge of electricity entering the building along the telegraph wires. Probably all this loss would have been prevented had the ordinary lightning arrester been provided upon the posts near the building. The arrester is simply a wire that has one extremity placed very near but not in contact with the telegraph wire. The other extremity of the arrester terminates in the ground. When lightning gets on the telegraph wire it leaps to the arrester wire and passes into the ground.

Electric Blowpipe.—At a recent meeting of the Academy of Sciences, M. Jamin submitted a new electric burner, which he also recommended to chemists and physicists as a blowpipe. Two carbons are supported vertically abreast, hinged below, and drawn together at the top by a spring. A current is sent up one, down the other, then round a rectangular circuit enclosing the two, and passing first round the first one by current attraction the carbons are drawn apart, and the arc appears at the top and descends gradually, consuming one or both carbons. When the action of the rectangle is sufficient, the arc driven beyond the points is like a gas flame, and M. Jamin receives it on a piece of lime, magnesium, or zirconium, getting intense light. It is also so hot as to fuse the lime. For the electric light this burner has considerable advantages, since it has no mechanism and requires no preliminary preparation beyond a support and the carbon points. The size of the flame is almost doubled, and the light is augmented. The new foci are very powerful, and the quality of the light is far better, and the arrangement of the foci is more advantageous, the greatest quantity of light being directed downward, where it is wanted, instead of up into the air, where it is useless.

Electricity in Naval Affairs.—It is now proposed (says *The Times*) that the officers undergoing a course of torpedo instruction on board the Vernon, at Portsmouth, shall also be required to familarise themselves with the practical application of electricity to the art of war. The teaching element has not as yet been perfected, but proper instructors will, no doubt, be provided in course of time. Steam was got up in the Dreadnought on two occasions, and the first lessons in the production and management of the electric light were imparted. The turret ship is provided with a couple of lamps placed at each end of the flying deck, the current being generated by one of Wilde's electro-magnetic machines, the motive power for which is supplied by a strap from the forward ventilating engine. The illumination is produced by a couple of vertical carbon points, which are worked by hand. There is no subdivision of the current, so that only one light can be used at a time. Until lately, however, the after light could only be obtained by disconnecting the forward one and forming a new and separate connexion with commutator between decks. This method not only entailed great loss of time, but was attended with great difficulty. Now, however, an important improvement has been introduced, by means of which it is only necessary to shut off the forward connexion, and the after light may be used at once. Some experiments have also been made with the Gramme machine on board the Bloodhound and a torpedo boat.

Nickel Deposition.—We hear from America that Mr. Edward Weston, of Newark, New Jersey, has made a discovery of great practical importance in relation to nickel plating. He finds that, when boracic acid, free or in combination, is added to any ordinary nickel-plating solution, the formation at the cathode of a subsalt of the metal is obviated, and that the deposited metal then becomes remarkably tough, coherent, flexible and smooth, malleable and ductile. The deposit is, moreover, said to be of a beautiful white colour, and to adhere firmly to the cathode; whilst the solution, instead of undergoing alteration and deterioration, permanently preserves its composition. Good solutions are made by using five parts of chloride of nickel to two parts of boracic acid, or three parts of sulphate of nickel to one part of boracic acid. These solutions are said to be improved by the addition of caustic alkali until the precipitate thrown down is re-dissolved. Even a small per-centage of boracic

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acid may be added with great advantage to solutions of the double chlorides of nickel and magnesium, sodium or calcium, and to all the solutions of either the chloride or the sulphate of nickel with sulphates of the alkalies or alkaline earths. Mr. Weston finds also that the borate of nickel, although insoluble in water, is very soluble in solutions of many of the salts of nickel; and that solutions of borate of nickel with salts of nickel afford a perfectly reguline deposit, and are especially efficient for electrotyping purposes, as well as for electro-plating.

NICKEL-PLATING.—We have long held the opinion that a large trade would gradually develop itself in Nickel-Plating, and from time to time we have noticed the correspondents of commercial papers taking a more decided tone about this business. The following note on this subject in support of our views is taken from the *Ironmonger*:—"The tinware and brassfounding industries continue to steadily call in the aid of the nickel-platers, to enable them to put upon the market wares having a finish about them which shall attract the attention of buyers. Cocoa and coffee urns, made of copper, for use in the coffee palaces, are being nickel-plated in considerable numbers, and they present, when completed, a smart appearance. Dish-covers, common circular tin waiters, tea and coffee pots, and the like, are also being turned out in increasing numbers by firms hereabouts in the nickel-plated state. Brassfounders are adapting the process in respect of taps and cocks for beer barrels, and for general beer engine fittings. Certain of the japanners still find it wise to produce trunks with the locks and other fastenings upon the front of the box nickel-plated. The light iron-founders find this American idea useful in regard, not only to coat and hat hooks, but likewise to bag and window fastenings. Several bicycle makers located in Wolverhampton have adopted the system with much spirit, the whole of the machines, before the various parts are fitted together, being pickled in the vats. These last-mentioned manufacturers, together with the makers of urns, have, up to the present, gone into the business more extensively than any of the other manufacturers of South Staffordshire. All the varied classes of work which I have mentioned are being nickel-plated by the Wolverhampton branch of the Plating Company (Limited), London, who, it will be recollected, have just opened another branch at Stockton, where they expect to do a good business with the makers of ship-fittings. The Wolverhampton branch report that the process is steadily winning its way, and that they have recently had to increase their staff of operatives. Orders, too, are reaching them from the tinware makers of Birmingham, from the fender and fireiron makers of Dudley (who have their goods bronzed), and just now from even as far away as Liverpool."

TRANSMISSION OF ACUTE SOUNDS BY THE TELEPHONE. BY PROFESSOR E. HAGENBACH.—The theory of Bell's telephone has essentially been established by Dubois-Reymond, Hermann, Weber, and Helmholtz. It has been admitted by these authors that the flexure of the iron plate is proportional to the amplitudes of the vibratory movements of the air, and to the variations of electro-magnetic potential of the magnetic masses constituting the telephone. It is not clearly evident *à priori* that a rigid plate of iron, even if thin, bends with vigorous and immediate obedience to the impulse of the forces acting upon it; with plates of a substance having low coefficients of elasticity, as india rubber, this is easily understood. Also, it is known that rigid plates can give only a limited number of true tones, and that the number of vibrations of these sounds depends partly upon the dimensions of the plate, its elasticity, and its density, partly upon the manner in which the plate receives its vibratory motion. The number of partial tones can with thin plates be very great, and if the vibratory segments are sufficiently numerous these tones may blend. The influence of internal inertia and of true elasticity diminishes with the amplitude of the vibrations, and disappears for infinitely small vibrations. It may be admitted that rigid and non-elastic membranes obey immediately and exactly the impulses recieved, similarly as do rigid plates where the vibratory amplitudes are infinitely small. In the telephone the amplitudes are very small, and the plate of the telephone may be considered to vibrate as a non-elastic membrane. To this fact may be attributed the remarkable property the telephone has of transmitting sounds. The rigidity of the plate may, however, make itself perceptible under some secondary circumstances and in some imperfections of the apparatus. The author seeks to elucidate this latter point. When a number of telephones are employed to transmit the sounds of a series of tuning forks, it appears that one telephone transmits relatively more clearly the sound of a particular fork, an experiment in which, however, subjective appreciation plays so great a part as not to admit of satisfactory conclusions. But in the use of Koenig's apparatus for measuring the limits of acute sounds, personal error disappears. The author carried out a series of experiments in M. Hipp's workshops at Neuchâtel, introducing successively into the telephone plates of iron varying from 0·005 inch to 0·007 inch in thickness, and found that for sounds heard through the telephone the limit of audition is about two octaves lower than for sounds heard directly, the cause having been proved to exist in the instrument, and not to arise from defective personal audition. It remained to determine the locality of the defect, whether in the circuit, magnet, or iron plate. That the circuit is not the locality is proved by the small effect of introducing resistances; also interchange of magnets produces no definite result; whereas, changing the plate modifies the limits of audition. It may, therefore, be affirmed that when the number of vibrations per second, and consequently, that of the changes of magnetism, surpass a certain limit, the plate cannot respond to the rapid alternating impulses. This is easy to be understood, when it is considered that the plate of iron before obeying the directive impulse has to overcome its own tension and molecular friction. If the time necessary to surmount these resistances is as long as the interval separating the alterations of vibratory movement, these latter neutralise each other, and the effect upon the plate is annulled. The same thing occurs with the water manometer, which remained immovable under the too rapidly succeeding impulses of a sonorous tube,* or with a galvanometer which remains insensible under the action of the alternating currents of an induction coil or telephone. It is probable that the limit of audition is lower with thick than with thin plates; but this assumption is not always confirmed, since plates present different qualities of elasticity and rigidity. It is to be expected, and is confirmed by experiment, that the true tones of the telephone-plate are those best transmitted. As far as the author can judge by some direct trials, the phonograph is less sensitive than the telephone to acute sounds. The sounds from the Koenig cylinders are not recorded by the phonograph, and this explains why the instrument only imperfectly imparts the proper timbre to the vowel I.—*Annalen der Physik und Chemie*, 1879, p. 407.

* A. Kundt. "On a Maximum and Minimum Manometer for Measuring Variations of Pressure in Sonorous Tubes." *Ann. Chemie und Physik*, vol. cxxxiv., p. 563.

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PRACTICAL DIVISIBILITY OF THE ELECTRIC LIGHT.*

(CONCLUDED FROM PAGE 131.)

In the following paper will be found some additional data in support of the statements made in our previous communication upon our new system for the practical divisibility of the electric light.

I.—NUMBER OF CANDLES OBTAINED PER HORSE-POWER.

Mr. H. Fontaine, a well-known scientist, and a recognised authority in matters pertaining to electricity, declared previous to 1878 that he has several times obtained electric light at the rate of 1,900 candles per horse-power.†

Mr. Tresca, of the French Institute, reported to the Paris Academy of Sciences his experiments made in 1875, when a Gramme machine of about 18,000-candle power rendered 241 carcel burners (2,270 candles) per horse-power.†

In the experiments made in 1876-77 at the South Foreland lighthouse by Professor Tyndall and by Mr. J. N. Douglass, the Secretary Engineer of the Trinity House Board, they obtained 1,291 candles per horse-power.‡ In 1877 said Mr Douglass saw at Paris a small Gramme machine giving 3,000 candles per horse-power, and he adds that the factory had just sold a larger one giving 3,839 candles per horse-power.§

In August, 1877, Mr. J. N. Schoolbred, member Institute C.E., stated at a lecture that the Gramme machines could give 3,000 candles per horse-power.||

In the *Scientific American Supplement* of March 9th, 1878, it is said that the electric light was tried in Paris at the Palais de l'Industrie, where a space of 12,000 square metres was illuminated by two electric lustres of six lamps each; that two steam engines of 25 horse-power each were used, and the light was equivalent to about 300,000 candles, which gives about 6,000 candles per horse-power.

We will now remark the fact, that the larger the amount of electricity produced by a dynamo-electric machine, the larger is its light-giving capacity per horse-power spent. This is in accordance with that electrical law mentioned in our previous communication, and quoted among others by Wm. H. Preece, of London,¶ and by Prof. John Le Conte, of California.** The law is, that when an electrical current is divided into sub-currents, the light-giving power of each sub-current is less than inversely proportional to the square of the number of currents. It is then natural that when several currents are added together, the result will be larger than the sum of the separate currents, as was practically shown by the experiment made by Prof. Tyndall at the South Foreland Lighthouse.††

He had two small Siemens machines of a power of 4,446 candles the one and of 6,563 the other, making in all 11,009 candles; yet, when they were coupled so as to feed one single lamp, the light produced was 13,179 candles, or 19·7 per cent. over the former figure, with the same expenditure of power; or else they could have produced the same amount of light with less expenditure of horse-power.

It has also been found that whenever the power spent in a machine is increased, the light produced increases in a greater proportion than the power. And finally, if instead of adding or coupling together two separate currents, we produce a single current in a single machine with a power equal to the sum of the powers spent in the two former currents, the result is still greater than twenty per cent. over the sum of said two currents, as will be seen in the following table:—

Name of Machine.	Maximum capacity in Candles.	No. of Candles Fed.	Horse-Power Required.	No. of Candles per Horse-power.
Gramme......	4,000	1	2	2,000
	6,000	1	2½	2,400
	15,000	1	5	3,000
	25,000	1	8	3,125
	36,000	1	10	3,600
	50,000	1	13	3,846
Brush.........	4,000	1 or 2	3½	1,143
	12,000	4, or 5, or 6	6½	1,846
	35,000	10 to 18	13	2,691

* A paper, by E. J. Molera and J. C. Cebrian, read before the California Academy of Sciences, May 5th, 1879.
† H. Fontaine, "Eclairage a L'Electricite." Paris, 1877.
‡ *Engineering*, Oct. 19th, 1877.
§ *Engineering*, Nov. 2nd, 1877.
|| *Engineering*, Nov. 1st, 1878.
¶ *Engineering*, Jan. 24th, 1879.
** *Scientific Press Supplement*, No 3.
†† *Engineering*, Oct. 26th, 1877.

The smaller duty, or production per horse-power, of the Brush machines, is because they are made to feed several lamps, whereas the Gramme machines feed one single lamp; so that the Brush machines may be considered as a combination of two or more machines of about 2,000 candles each, built so as to combine together two or more of them in one; thus, the 12,000-candle machine acts as a combination of six machines of 2,000 candles or less each, which may work independently or in combination of two in one. The difference lays in this: that six separate 2,000-candle machines would require a power of twelve horses, and by their combination in one machine, the required power is reduced to 6½ horses. All of which corroborates the above stated fact, and clearly proves that if, at present, the duty of dynamo-electric machines is from 2,000 to 6,000 candles per horse-power, with expenditures varying from 2 to 25 horse-power, when we have a machine built so as to be run by 100 or 500 horse-power, its duty will certainly increase in a large proportion.

Such machines have not been built, because there has been no demand for them. A powerful focus of light has no practical application but for lighthouse purposes, and even in that case the intensity is limited; first, on account of the geographical range, further than which no light can be seen; and second, because in thick weather a large increase in intensity does not increase the optical range but in very few feet. In fact, the only serious objection made to electric light has been its too great intensity, as being inadequate to the general purposes of lighting. For instance, four lamps of 2,000 candles each, making in all 8,000 candles, and being properly distributed, will give for a large space a more efficient illumination than a single lamp of 12,000 candles. Thus, a check has been put to the makers of dynamo-electric machines; and the extent of the practical capabilities of such machines has remained necessarily unknown. But as soon as the economical divisibility of the electric light be proved as a fact, larger machines will be built which will take advantage of the above-mentioned fact or law, and will cause the further cheapening of the electric light.

Another fact that proves the correctness of the above theory, which we have seen coincides so well with the practical results and experiments of the above-mentioned scientists, is the following results, obtained by Prof. J. W. Draper, of New York, who in his researches on radiant heat found that the light of ignited platinum at 2,590° was more than 36 times as brilliant as when the temperature was only 1,900°.*

Now, the temperature produced by mechanical means is directly proportional to the work, yet the light corresponding to the increase of work or heat is a very rapidly progressing proportion.

II.—COST OF ELECTRIC LIGHT.

Mr. R. Briggs, C.E., of Philadelphia, has calculated the theoretical relation of the values of gaslight and electric light, taking as basis the very low figure of the experiments of the Franklin Institute; and computing the heat-unity absorbed by a standard candle produced by coal gas and by electricity, he finds:—

$$\frac{\text{Heat units consumed by gaslight}}{\text{Heat units consumed by electric light}} = \frac{100}{1}.$$

But considering that in those experiments only one-third of the horse-power was spent in the light, and the other two-thirds were necessarily lost, the above relation is reduced to 34 ÷ 1.† We must remark, however, that the Franklin Institute experiments, showing 380 candles per horse-power, must have been made with inferior kinds of dynamo-electric machines, as other competent experts of different countries find a duty per horse-power over five times greater; in which case the above relations would be more favourable still to the electric light; and even President H. Morton, who is not an advocate of the electric light, stated in 1878, that the Brush and other machines, render light up to 1,200 candles per horse-power.‡

Similarly to Mr Briggs's method, we may find the practical relation between the costs of the two lights, as follows:—One cubic foot of gas comes from one-quarter pound of coal; one pound of coal is equivalent to 15,000 heat units; therefore 15,000÷4=3,725 heat units correspond to 1 cubic foot gas. Now the merchantable residues of gas making amount in Bristol to less than 30 per cent. of the cost of coal;§ and in America to much less than in Bristol.|| Allowing then 30 per cent., we must subtract from the 3,725 units 30 ÷ 100 × 3,725 = 1,117, leaving thus 3,609 heat units corresponding to 1 cubic foot of gas, which equals 3 standard candles; hence a standard candle represents 3,608 ÷ 3 = 1,203 heat units expended.

* J. W. Draper's "Scientific Memoirs," p. 41, N.Y., 1878.
† *Engineering*, October 18th, 1878.
‡ Address before the American Gaslight Association.
§ *Engineering*, December 27th, 1878.
|| S.F. Gas Co. Reports.

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Now, for electricity, we know that a horse-power consumes from 2 to 6 pounds of coal per hour; taking the 6 pounds, 1 horse-power will be equivalent to 90,000 heat units per hour; if we call N the number of candles produced by 1 horse-power, 90,000 ÷ N will represent the number of heat units per candle power spent by electricity; the relation then stands:—

$$\frac{\text{Heat consumed by gas}}{\text{Heat consumed by electricity}} = \frac{1,203}{\frac{90,000}{N}} = R; \text{ therefore}$$

$$\text{When } N = 500 \text{ candles, then } R = \frac{6 \cdot 6}{1}$$

$$\text{,, } N = 1,000 \text{ ,, ,, } R = \frac{13 \cdot 2}{1}$$

$$\text{,, } N = 2,000 \text{ ,, ,, } R = \frac{26 \cdot 7}{1}$$

$$\text{,, } N = 3,000 \text{ ,, ,, } R = \frac{40}{1}$$

And so on. These relations are not exaggerated because we have to add to the cost of the fuel the cost of carbon points.

This is why Dr. Siemens, of London, said that one pound of coal thrown into the engine that drives an electric machine, will give 15 times more light than if thrown into a gas retort to make coal gas.*

This also proves the assertion of Mr. H. Fontaine, mentioned above, who, after several years of constant experiments, and careful attention to this subject, has come to the conclusion, since 1877, that whenever the electric light is produced in quantities of 300 candles or more, it is cheaper than gaslight, and when produced in amounts of 7,500 candles and over, even if three-fourths of said amounts are wasted, the electric light is much cheaper than gaslight.

For practical instances of the cheapness of the electric light we will remind you of the trial made as early as in 1873-74 at the tower of the Houses of Parliament, London, where an old pattern of the Gramme machine was used; the light was of 7,000 candles; its actual cost one-eighth the price of London gas.†

Later, the comparison between the two lights made by the engineers of the Trinity House Board was that, when the intensity of gaslight was two-thirds of that of the electric light, the cost of gas was one-third above that of electricity.‡

Again, the use of the Jablochkoff system at the Hotel and Magazines de Louvre in Paris for over eighteen months since 1877 shows that they are spending for light two-thirds of what they used to pay for gas bills, and they get nearly three times as much light as before.§ We will remark that the Jablochkoff is not the cheapest electrical system.

Then, we have the instance of the Albert Hall, London, last February, where the actual cost of the electric light was one-third the amount of the gas bill, at London prices; and which, at the San Francisco prices, would have been less than one-sixth the cost of gas.||

Then we have the statement of Mr. Geo. Deacon, the engineer of the town council of Liverpool, who was sent to Paris during the summer of 1878, for the especial purpose of studying the lighting question. In his able and full report, he advises the town council not to adopt yet the electric light, on account of the difficulty of managing it. But he admits, as far as the cost of production goes, that when produced at the rate of 15,000 candles, the cost of electric light has been as low as one-fifth the cost of gaslight.¶

Then, Mr. J. N. Shoolbred, already mentioned, brought to notice, last December, several instances of actual practice, where the cost of electric light is a fraction of that of gaslight.**

Finally, Mr. J. N. Douglass, also mentioned above, at a lecture delivered last March, stated the conclusions arrived at, after the extensive and exhaustive experiments carried on at different times by the Trinity House Corporation. He said that for an intensity of light of 5,000 candles and upwards, electric light is cheaper than gaslight; that for said intensity of 5,000 candles, the cost of electric light is less than half the cost of gaslight; and that electric light decreases in cost per unit in ratio of its augmented power, no further addition to the working staff and but little extra expenditure for buildings and plant being necessary for an intensity of 40,000 candles.††

To present any more practical instances would be tiresome for you.

Here we have the definite statements of several experts, all well qualified in every respect for this question; they take different series of experiments, made at different localities, as basis for their assertions; and they all come to the conclusion that in amounts not larger than 15,000 candles, electric light costs from one-fifth to one-eighth of the cost of gaslight. And one of the experts declares that practice corroborates the fact that for larger intensities the cost per unit of electric light decreases in ratio of its augmented power.

Therefore it is quite natural that when the electric light be produced, not in amounts of 15,000 candles, but in amounts of 1,000,000 or 2,000,000 candles, its cost will not be more than one-twentieth that of gas, as we had stated.

III.—LOSSES OR WASTE OF OUR OPTICAL SYSTEM.

These are due to the reflections and refractions of light; and to the absorption of the atmosphere on account of the distance travelled by the light.

There will be not more than six reflections or changes of direction of light needed to put our system in practice.

In the streets we can always go from a crossing to any place in a city, having rectangular blocks, with one change of direction. Only in the case of going into an ally in the middle of a block, there will be needed two changes. Considering that such cases are comparatively few, and that the streets where the main beams of light are have no change of direction, we may say that one change of direction or one reflection is needed to supply streets with light.

For buildings we need one change of direction from the street main to the service pipe; a second change from the service pipe into a vertical supply pipe; a third change from the latter into the different horizontal supply pipes for every floor; the rooms that are not in the line of the horizontal supply pipe need a fourth change from it into a lateral branch; then we need at every room a fifth change of direction to go from the last pipe into the room. That makes five changes of direction or five reflections, at most, needed to supply a building with light.

The street lamps will need from two to four reflections, according to location. The sum of all these reflections gives an average of less than six, as said before.

Then our light has to pass through the primary lenses or chamber of light, and through the secondary lenses. Every time that light passes through one lens, it loses about 6 per cent. of its intensity, according to the mean of Sir J. Herschel's and Lambert's experiments.*

And according to Sir J. Herschel† and Dr. Lommel‡ the loss of light by reflection is:

After reflection on polished glass	about 96 per cent.
,, ,, ,, mercury	,, 40 ,,
,, ,, ,, polished speculum metal...	,, 34 ,,
,, ,, ,, ,, silver	,, 9 ,,
,, ,, through a totally refracting prism	,, 8 ,,

Therefore the losses of our system will be: First, a loss of 6 per cent., then six successive losses of 8 per cent. each; then another loss of 6 per cent.

If we call L the intensity of the original light, and L¹ that of the distributed light, the formula to find L¹ will be this:

$$L^1 = \frac{L \times (94)^2 \times (92)^6}{(100)^8} = \frac{53 \cdot 57\ L}{100};$$

the loss, then, amounts to 46·43 per cent.

As for the loss due to absorption in the travel of light along the tubes, we find that according to accurate experiments made by Mr. Bouger,§ a well-known French scientist, light loses 2·7 per cent. in intensity after passing through a stratum of pure atmosphere one kilometer in thickness. Then, Major P. C. Hains,|| the Engineer Secretary of the L. H. Board, U.S.A., says that according to experiments made all along the Atlantic coast, the transparency of the atmosphere is such that, during six months in the year, light will lose only 9·7 per cent. in traversing said distance of one kilometer; that in some cases the transparency is such as to cause a loss of only 3·4 per cent., although in some cases the loss amounts to 25 per cent.

Now, considering that the pipes enclosing the light are not subject to the atmospheric changes of weather that occur along the shore line where said experiments were carried, we may safely assume that in our case, we will not lose more than 10 per cent.

* Siemens, Annual Address, *Engineering*, February 8th, 1878.
† *Engineering*, December 20th, 1878.
‡ *Engineering*, December 20th, 1878.
§ *Engineering*, December 27th, 1878.
|| *Engineering*, February 28th, 1879.
¶ *Engineering*, February 21st, 1879.
** *Engineering*, Dec. 6th, 1878.
†† *Engineer*, March 28th, 1879.

* "The Telescope." By J. Herschel, "Encyclopedia Brit."
† "The Telescope." By J. Herschel, "Encyclopedia Brit."
‡ Dr. Lommel, "Nature of Light."
§ L. Reynaud "Lighthouse Illumination." Translated by Major P. C. Hains.
|| L. Reynaud "Lighthouse Illumination." Translated by Major P. C. Hains.

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for that distance: 1 kilometer = 3,281 feet; calculating the losses for various distances, we find:—

Loss at 400 ft. distance	012
Loss at 800 ft. distance	023
Loss at 1,600 ft. distance	047
Loss at 3,200 ft. distance	097

In a city, the central stations of light, wherefrom to distribute it, need not be more than 6,400 feet apart. With such distances in San Francisco, four stations would be enough to supply all that part of the city inside of the charter line of 1851. In such a case the loss for the most distant point will be 9·7 per cent.; but the average loss will be that corresponding to a distance of 1,600 feet, which is 4·7 per cent. That loss, on our last amount of light of 53·57L, gives an additional loss of 2·52, which, added to our former loss of 46·43, makes a total loss of 48·95 per cent., or less than 50 per cent., and the formula, to find the final amount of light, *l*, received by the consumers will be:—

$$l = \frac{L^1 \times 95{\cdot}3}{100} = \frac{L \times 94^2 \times 92^6 \times 95{\cdot}3}{(100)^9} = \frac{51{\cdot}05\ L}{100}.$$

IV.—OTHER ECONOMICAL ADVANTAGES OF OUR SYSTEM.

But besides these losses, our system can easily take advantage of an additional source of light, because, as Mr. J. Jamin, of the Paris Academy of Sciences, stated last year,* the quinine sulphate has the property of changing the blue, violet, and ultraviolet rays into white light, and, at the same time, it renders visible and useful radiations which the eye could not perceive, thus adding considerably to the brilliancy or intensity of the light. Uranium glass, and many other substances, act in the same manner, and present the means of suppressing the rays which are objectionable in the electric light.

In order to take advantage of this property, we have only to surround any electric light by some of those substances. But in the methods of electric lighting heretofore proposed, where a great number of electric lamps are used, such a process would be extremely expensive, inconvenient, and liable to get out of order. Whereas our proposed method of distributing light renders that operation as simple and low-priced as possible; because we need to surround only *one* chamber of light with the required substance, and all the smaller lights fed by it, whether in hundreds or in thousands, will be affected accordingly. Consequently the loss of 49 per cent., hereinbefore mentioned, may, on account of this circumstance, be greatly reduced, with almost no expense.

Another of the great economical advantages of our new system of divisibility of the electric light upon any other is on account of the conductor connecting the generator of electricity with the lamp or lamps.

As we have said, the expense for electric conductors in a city will be enormous, but they have still another advantage as being a great source of loss of electricity. Mr. J. N. Douglass, in the experiments above mentioned, found that when the current of electricity travelled a distance of about 1,300 feet before reaching the lamp the intensity of light suffered a loss from 58 per cent. to 80 per cent., and for a distance of 600 feet from 27 per cent. to 37 per cent. Then Messrs. Siemens, the engineers, of London, furnished a larger cable as conductor. It was well insulated, and especially adapted for their dynamo-electric machines, and even then the loss of light in a distance of 1,400 feet varied from 23 per cent. to 35 per cent.†

As in our system of distribution of light the dynamo-electric machine may always be placed a few feet only from the electric lamp, it is evident that our system is the only one which can avoid both the high expense of cables and conductors, and the losses they produce.

In conlusion, we will compare the practical distribution of a light produced by a 25 horse-power engine, or 15,000 candle light, which is not the most advantageous case we might take, and we will see what amount of light we will obtain by the different proposed methods.

In the Jablochkoff method we will obtain 25 burners of less than 940 candles each, or less than 23,500 candles in the aggregate, provided it is possible to build a machine of 25 horse-power, feeding 25 lamps; heretofore only 16 or 20 lamps have been fed.

In the Edison system, according to the most recent reports, with 2½ horse-power engine, 14 lamps are obtained of from 18 to 20 candle power each. If we take a 25 horse-power machine we will obtain 10 times as much electricity, but then the number of lamps increasing to 140 for instance, the loss will increase in a larger proportion; therefore we will take 10 machines of 2½ horse-power each, and will obtain 140 lamps of 20 candles each.

* J. Jamin, "Electrical Illumination," *Revue des Deux Mondes.*

† *Engineering*, October 26th, 1877.

In the Brush system we will obtain 36 lamps, giving 70,000 candles in all. In the Werdermann system, 2 horse-power gives 10 lamps of 40 candles each; taking 13 such machines we would obtain 130 lamps of 40 candles. In our system we will obtain 82,500 candles, which can be divided into 8,250 lights of 10 candles each, or 4,124 lights of 20 candles each. Now we have:

Name.	No. of Lights.	Total Candle Power.	Adaptation.
Jablochkoff	25	23,500	Large spaces.
Werdermann	130	5,200	Small spaces.
Brush	36	70,000	Large spaces.
Edison	140	2,800	Small spaces.
Molera and Cebrian	8,250	82,500	Large and small spaces.

Or taking the horse-power per unit:

Name.	No. of Lights.	Candle Power.
Jablochkoff	1	940
Werdermann	5·2	200
Brush	1·44	2,700
Edison	5·6	112
Molera and Cebrian	3·30	3,300

THE STORM OF 2ND AND 3RD AUGUST.

The exceptionally violent thunderstorm of last Saturday night and Sunday morning appears to have extended over the greater part of England, and in many localities was accompanied with torrents of rain and hail. The lightning was of remarkable vividness and frequency; the average number of flashes, during a period of nearly two hours, being, in the vicinity of London, over a dozen per minute. Much damage was done by hail in the south and south-west suburbs of the metropolis; but the greatest fury of the storm seems to have been experienced in the valley of Gloucestershire and in the district of Monmouth, where it raged from six p.m. on Saturday till nearly six a.m. on Sunday. Telegraphic communication between Monmouth and Gloucester was for some time interrupted. Many of the people living in the vicinity of Dean Forest are described as being literally terror-stricken by the thunder and lightning; whilst at Buckingham this is said to have surpassed any that has been experienced for many years, and the quantity of rain per acre which fell during the storm is said to have been over seventy tons. In Norfolk, the church of Wells-next-the-Sea was struck by lightning and wrecked. The safety of Peterborough Cathedral was a subject of grave anxiety, as the building recently suffered during a comparatively slight thunderstorm; but, fortunately, the damage was not repeated. In Torquay, the lightning struck a chimney, which, falling through the roof into a room below, knocked the stove out of its place, and two ladies who were in the room had a very narrow escape. At Moulton, near Newmarket, some farm buildings in the occupation of Mr. W. Staples were struck by lightning and almost entirely destroyed. At Wilbraham the farm buildings in the occupation of Mr. Moore shared a similar fate. In Chad valley the storm was very destructive; the beautiful gardens being swept as by a tornado. The lightning struck a massive chimney in the gabled roof of the mansion belonging to Sir W. E. Chance, splitting it through the centre, and hurling about five tons of brick and stonework into the building; the hall of which, as well as some of the bed-rooms, became flooded by the rain. Fortunately, and curiously, all the inmates of the house escaped without injury. At Tivetshall, Cambridge, a man was struck dead by lightning; and in various parts of the country animals were similarly killed. Kew Gardens suffered very severely, for not only is an enormous amount of glass broken, but the flowers and shrubs are greatly mutilated. The gardens were, in consequence, closed to the public. On one side of Kew Green there is scarcely a pane of glass left whole, while the Roman Catholic Chapel at Richmond is a complete wreck. It is estimated that the damage done by the storm at Twickenham alone will amount to thousands of pounds. The Castle Hotel, Richmond, as far as glass is concerned, is completely wrecked. Some thirty guests were staying at the Orleans Club, and were witnesses to the devastation of not only the smashing in of the heavy corrugated glass forming the dome of the dining room, but the laying waste of the choice exotics in the beautiful grounds. The loss there alone represents over £1,000. Lady John Chichester's mansion, at the foot of Richmond Bridge, has suffered most severely, as also that of Mr. Grant Duff, M.P., at York House, Strawberry Hill, and Lady Adeliza Manners's outbuildings have been more or less reduced to a wreck; whilst those well-known strawberry growers, Mr. Richard Clarke and Messrs. T. and J. Smith, have simply acres of glass pulverised, involving a loss, irrespective of the fruit, of some hundreds of pounds.

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IS IT A HOAX?

This question was the immediate result of reading an article in an American paper which purported to describe a most wonderful discovery in electrical science. The use of the imagination in science has been dealt with by Prof. Tyndall, and we have no desire to follow in the same direction; still, we incline to the opinion that this able exponent might continue the subject with pleasure to many and profit to not a few. There is no scientific man worthy of the name who does not constantly sit absorbed over the fleeting fancies of his mind, vainly endeavouring at times to get a glimpse of light from the chaos, at other times making a decided and definite step onwards after a mental picture of the action of a conglomeration of molecules under a variety of circumstances. He decides upon a direction in which to experiment, and he experiments with results similar to those imagined during his mental study.

We are all agreed that sound is the result of a vibratory movement—the movement of matter of a comparatively ponderous character. It would, perhaps, be better to say that the auditory apparatus of mankind is adapted to hear only vibrations of this character, for we have no reason to think the vibration is absent when a bell is struck in a vacuum; it is rather that the vibrations are too weak to excite the apparatus. If, then, we supplement the normal apparatus with other means, sounds hitherto unheard become audible. Light, again, is caused by vibrations—in this case, however, not the vibrations of ponderable matter, but of something, so far as we are concerned, hardly to be grouped under the heading of "ponderable matter." That "ether" possesses some consistence, some ponderosity must be admitted, if astronomical statements are correct, that the terrestrial day is lengthening because of the friction between the earth and the "ether." Starting with knowledge of this kind, and allowing the imagination a fair amount of freedom, is it too much to say that the "ether," if there is in reality such a thing, will ultimately be brought under the cognisance of the human brain, to be weighed and measured and discussed, just as hydrogen is weighed, measured, and discussed. Further, if the sound waves can be transmitted by means of electrical apparatus from one place to another place many miles distant, cannot we conceive the possibility of transmitting the light waves in a similar manner, but with more delicate apparatus, probably differing altogether from any with which we are now acquainted? Who thought, a hundred years ago, of weighing, so to speak, one electric current by means of another, and who will be bold enough to say what can be done yet by means of electricity? The apparatus now applied to electrical work is of an extremely delicate character compared with that in use some fifty years ago, what it may be fifty years hence no one knows.

What, however, has this to do with the paper read?

It seems that Western America is very much interested in electrical work, and several popular publications endeavour to supply the required information. One of these contains an account of an experiment which proved so successful that the gallant inventor is travelling eastwards to astonish, first the leading cities of the States, then benighted Europe. A quiet, sedate, hardworking, careful captain devotes his time and attention to the study of electricity. We have endeavoured to give a sketch of what might be his style of reasoning, and the result is experiments upon the transmission electrically of light. The reporter describes the room, but not the apparatus, he, like the writers of stray books on wizard lore, speaks of a small mirror over which hangs a green curtain. The successful experimenter describes how he will attract the attention of his colleague, in another part of the city, with whom he has electrical communication. The circuit is completed, the call is made, the answer given, the green cloth is removed from the surface of the mirror, and lo! the reporter beholds the features of an unknown person. It is explained that the features shown in the glass are those of the assistant at the other end of the line. The assistant is then told to transmit a representation of the room in which he is acting his part, and immediately the picture in the glass gives place to another, that of a room furnished in a manner which is minutely described. The climax is reached when the view of the street in another part of the town is shown.

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There can be no mistake, the reporter thinks—he knows the street, the scene is familiar, the houses are distinguishable, and he hails the whole as a complete success.

Possibly, some young gentleman of a scientific turn of mind has personated the Editor, with the connivance of the latter, who desired to rival his Eastern contemporaries in sensational science. At any rate, the question arose, is it simply imagination, or is it a hoax? The idea of transmitting light is not new, and it is only when we consider the difference between the vibrations causing light and those causing sound that we feel the enormous strides to be made before the possibility of transmitting a whole picture, with its varying tints of colour, can be admitted. As we have previously said, both are forms of motion; success has been achieved in the one case, what of the other? There is no difficulty in admitting the possibility of transmitting colours by electricity. The hiatus necessary to be filled in our existing apparatus is known. We require—but it is doubtful if we ever obtain—colours which, on the passage of an electrical conductor over them, give rise to a varying current, and a chemical compound which, under the influence of a varying current, gives the corresponding colours.

We have not attempted to describe the means by which Captain Jaques D'Arcy is said to achieve his results, because we think the means utterly inadequate to obtain such results. The question remains. Is it impossible to transmit light waves in a manner similar to the telephonic or microphonic transmission of sound waves? and if so, what causes the impossibility?

CORRESPONDENCE.

ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Before replying to Mr. FitzGerald's letter in your last issue, I must first make a personal request to him, and that is, that he will kindly refrain from using the expression, "Dr. Lodge and his school," or similar words, which, though they might properly be applied to a leader of thought, have only a ridiculous effect when applied to a student like myself. And another thing which I have several times wished to set him right about is that I am not, and do not pretend to be, a mathematician. I have studied physics (like himself, probably) from below upwards, beginning with amateurish construction of instruments and the like, and not for a long time acquiring any available knowledge of mathematics at all. So that he is in error if he regards me as in any sense a representative of a (hypothetical, but to some extent existing) class of mathematicians who, starting with high priori notions, grind away at several alphabets of symbols, and evolve from them new combinations which they sometimes leave in that form and sometimes endeavour to impose upon the facts of nature, wrangling with, and torturing them till they show some signs of conformity to their formulæ.

And now with regard to Mr. FitzGerald's letter. The arguments in the longest paragraph are beyond me. For instance, I do not know what measuring a thing as E or as $\sqrt{E}$ means. But I find that he considers all modern physicists who have made electricity a special study as seriously and inexcusably wrong about something. I say *all*, for though a few, like Mr. Sprague, may agree with him in postulating a great error somewhere, yet I do not imagine that these gentlemen would approve of each other's notions much more than they approve of those of physicists in general. But these physicists have, at least, the merit of agreeing tolerably well among themselves. Now, surely a man would be rash who should resolutely maintain his own watch to be correct in the face of all the concordant timepieces of his village, even though his own were best London make, and the others belonged to the parish church, the School Board, and the workhouse.

This is a feeble kind of argument I am aware, but really I do not know how to meet his longest paragraph in any other way.

His next paragraph, however, is more definite:—"If such a force exist it must be altogether distinct from that which produces the effects of electrical attraction and repulsion." Certainly it is: utterly and entirely distinct. This last is a mechanical force and acts upon ordinary matter.

With regard to the next and last paragraph, I am afraid I must plead guilty to complete and entire ignorance of the "law."

$$Q=\frac{\sqrt{F}}{R}$$

I have not the least idea what it means. But Mr. FitzGerald referring to my last letter asks me whether in that letter I did not make a lapse and say *multiplied* by a length when I meant *divided*: and whether by a *length* I intended a *resistance*. No, Sir, I meant multiplied; and by a "length" I did not mean a resistance but simply a distance. I thought it would be apparent that I was referring to Coulomb's simple law

$$F=\frac{Q\,Q'}{d^2},$$

which gives the dimensions of Q as equal to $d\,\sqrt{F}$.

I rather regret this last letter of Mr. FitzGerald's. I had been hoping that our opinions were somewhat approximating; but the chasm between our views is now apparent again, and seems wider than ever.—Yours, &c., OLIVER J. LODGE.

ELECTRICAL TREATMENT OF WRITER'S CRAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: No one would wish to depreciate in the least degree the credit due to Mr. Edison as a most energetic labourer in the field of electric science, nor to rob him of the results of his inventive genius. But when he is "cracked up" as the only man to whom we can look to solve the problem of lighting our houses by means of electricity, I, for one, object. He is now going through that process, which all who have worked in electricity have had to go through, careful and arduous experiment. Is it to be supposed that Mr. Edison can jump at results, without having to go through all that preliminary training which our great English electricians have had to go through? Emphatically, no!

Mr. Edison has not thought it worth his while to take advantage of the labours of others; he must, therefore, do the work for himself, and may he succeed is my earnest wish.

My object in writing to you is to call your attention to two paragraphs you have culled from American papers in your "Notes" of last week—"A case of blindness cured by electricity" and "Electrical treatment of writer's cramp." Now, if you will turn to the old *Electrician* of 1863-64, you will find that a fair portion of the journal was devoted to medical electricity, and that a great many useful facts were recorded weekly under that head. If you, as the representative of the telegraph electricians of England, are willing to yield the palm to the electricians of America, I, as an Englishman, am not willing to do the same as regards electricity. Should you really wish to open your pages to this branch of the science, I shall be willing to let you have original papers, so that you need not have to cross the Atlantic for your material.—Yours, &c., HARRY LOBB.

31, Sackville-street, Piccadilly, July 28, 1879.

[We shall be pleased if Mr. Harry Lobb will favour us with an occasional contribution on questions connected with the important subject of medical electricity.—ED. *E.*]

CONSTRUCTION AND TESTING OF LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Repeated instances of the inefficacy of lightning conductors, as ordinarily constructed, have led me to the following conclusions:—

1st. That the resistance of such conductors, together with that of their earth-contacts, should in all cases be periodically tested.

2nd. That greater attention should be given to the means for establishing good and *permanent* earth-contact.

The resistance of a lightning conductor and its "earth" should be only a small fraction of one ohm; and an impression prevails amongst some electricians that it is difficult if not impossible to measure with accuracy such small resistances. Any difficulty that may have existed in this direction has, however, been overcome in certain modern methods of testing, such as that described on p. 211, Vol. I., of *The Electrician*.

In regard to the earth-contact, when gas or water pipes cannot be utilised, a large sheet of zinc, in contact with the copper conductor and with moist earth, fulfils the purpose in view during a considerable period of time, whilst protecting the conductor from oxidation. But the only really permanent earth-contact I

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know of is effected by means of a short and stout platinum wire imbedded at one extremity in the copper conductor and at the other extremity in a large fragment of gas-carbon, surrounded with a few hundredweight of coke in contact with moist earth. In this case the whole of that portion of the copper conductor which is in contact with earth and platinum should be well insulated with gutta percha or paraffin-compound, so as to avoid oxidation by voltaic action.—I am, &c.,

DESMOND G. FITZGERALD.

ON THE MEANS OF MEASURING THE ELECTRIC LIGHT.

BY FRANK GÉRALDY.*

[This article, referred to in our leader last week, was unavoidably postponed until the present issue.]

Should we want to make ourselves disagreeable to any person engaged in electrical applications, we have only to ask him to state accurately, and in figures, the luminous value of a given apparatus. The more the electrician may be conscientious and advanced in knowledge, the more will be the likelihood of obtaining the following answer:—"This question has been much studied, the Americans think that we should say so much, the English think that the figure is too high by a third; as for myself, my experiments lead me to conclude that it should be augmented, but do not allow me to accept the determination of Mr. X., according to which the value should be doubled. I will not quote to you the figure given by the inventor, because it is exaggerated." And, at the end of this, we are as wise as at the commencement.

This vagueness is due to several causes. The thing to which the measurement relates is itself variable, and, in spite of all the investigations which have been made, it is still imperfectly understood. The generators of electricity are not constant; the smallest variations in the resistances influence their effectiveness to such an extent that if we successively connect two different apparatus to the same source, we may say that they are not working under the same conditions.

But, outside of all these experimental difficulties, there is one very effective reason which has first to be considered, viz., that we do not know, or we know badly, how to measure light. In relation to this matter, the means at our disposal are almost all imperfect. The foremost element, the unit, is a rough one and ill-defined. The English reckon light in candles, each of which has a value of about ·8 of a *bougie de l'étoile*; we reckon in *becs Carcel* burning 40 or 42 grammes of oil per hour, the value of this unit being about nine and a half times that of the former one. Others use a gas burner, somewhat more luminous than the Carcel burner, but approximating to it.

Such are about the terms that one meets with at every step when we have to correlate units the ratio between which should be so accurate. This is not to be wondered at; for how are we to compare things which do not remain equal to themselves. Any person who has once in his life observed, burning side by side, two candles or two lamps reputed to be similar, will know how to estimate the precision of the luminous units.

But, even if we admit that it may be possible to give to the various sources taken as units all the constancy that is necessary, and that their ratios may be determined mathematically, there still remains an element of difference which it is impossible to obviate, viz., that of colour, each of these sources giving, in fact, a differently constituted light.

No doubt the notion of intensity may be separated from that of tint; one may very well conceive of the numerical valuation of a quantity of light, independently of its nature; but if this is possible mathematically it is, physically, surrounded with difficulty.

It will, in fact, be readily understood that when one person has decided that two rays of the same colour, red for instance, are equal, another person, whatever may be his eyesight, will naturally agree with the conclusion, since the objects to be compared are of the same nature; but if one person has admitted the equality in point of quantity of two rays, one of which is red, and the other violet, we cannot be certain that another person will arrive at the same judgment, since his perception in regard to these colours may be different to that of the former observer, and we cannot, moreover, say that the one is right and the other wrong. In the selection of our luminous units, this difficulty, well known to all who have had to perform photometric experiments, was not taken into account.

* Translated from *La Lumière Electrique*.

Nor is it obviated in our photometric instruments.

We know that these arrangements do not aim at determining the ratio of two unequal lighting powers; they can only indicate an equality. When we have to deal with two unequal sources, the stronger is put further off until its intensity is the same as that of the weaker; then, measuring the distances of the two sources from the apparatus, the ratio of the squares of the distances will be the ratio of the lights.

To indicate this equality, the most ingenious means is, doubtless, that supplied by Wheatstone. His photometer is composed of a small ball of polished steel, to which a rapid movement of translation is given by means of a crank. This little mirror is placed between the two lights, which are reflected as two brilliant points; the ball is then set in motion, and transforms these points into two luminous ribbons in juxtaposition to each other, and of which the relative brilliancy is tolerably appreciable.

The photometer of Foucault is simpler and of easier manipulation. It is a plate of ground glass, divided by a partition so that each half may be illuminated by one only of the luminous sources to be tested.

In these two instruments two lights are compared, subject completely to the disadvantage which has been pointed out. It should, however, be observed that the second apparatus has received an important improvement by the addition of coloured glasses suitably selected so as to correct the difference of tints and produce a similarity of illumination. By this means comparison is rendered possible and precise; but the accuracy of the measurement is not certain, since the intervention of coloured glasses produces some alteration in the lights experimented with. No doubt it would be possible to ascertain beforehand the variation produced in the light to be measured by the introduction of the coloured glass, and to make a correction by means of a suitable coefficient; but, up to the present time, the requisite data are not known.

These disadvantages have perpetuated the use of Rumford's rod-photometer, with which, instead of comparing the brilliancy of two lights, we equalise the intensity of two shadows. We do not here completely obviate the effect of the diversity of colours; for it is known that a shadow has always the tint which is complementary to that of the source; but the effect is less marked.

In the photometer of Bunsen, comparison is again made between two lights, but by the aid of an ingenious artifice. We know that a drop of oil on a sheet of paper gives to it at the point where it is applied a peculiar appearance and translucency. This effect is perceptible only when the sheet of paper transmits light, that is to say when its two faces are unequally illuminated; and the spot ceases to be visible when the illumination is the same on the two sides. It is easy therefore to realise the apparatus. A sheet of paper with a spot of oil upon it is placed between the two sources of light to be compared, on the line which unites them, and the position of the sheet is varied until the spot disappears; we have then only to measure the distances.

An apparatus of this kind was constructed some years ago by M. Dove. It appears to have remained but little known, and yet it seems very well adapted for the measurement of lights, especially of the electric light; it is recommended by several electricians who have used it, and it may be useful to refer to it as though it were new.

The special peculiarity of the instrument is that it is but very little affected by colour. In carrying out this principle, Dove makes use of a photographic image on glass representing printed characters; for instance the photograph of a page from a book. This he observes under the microscope, whilst illuminating it above and below. According as one of the lights is stronger than the other, the characters appear in white on a black ground or in black on a white ground. The eye is very sensitive in determining the moment at which light is transmitted, whatever may be its colour. In order to compare two sources of light, we must be able to place them successively in the axis of the microscope, which is placed horizontally; the photograph is illuminated laterally by the rays from a constant source; then one of the sources to be measured is brought in the line of the axis and placed at such a distance as exactly to compensate the effect of the constant source, *i.e.*, so that the photographed characters may no longer be visible; the second source is then substituted for the former, whilst the lateral illumination is maintained constant; and compensation is again obtained. The measurement of the two distances at which the compensation has taken place allows of the intensities being compared.

The principle, it will be seen, is very similar to that of the Bunsen photometer; the special advantages of the apparatus are due to the use of the letters used in printing, to which the eye is thoroughly accustomed, and to the introduction of the microscope, which allows of greater precision.

Whatever may be the merits of this apparatus, it is questionable whether photometry will make any serious progress so long

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as it is confined to the direction hitherto followed; and we may expect shortly to see great modifications introduced in this kind of measurement. One of the first will doubtless be the classification of lights according to their nature; instead of comparing *en bloc* two dissimilar luminosities, we shall become accustomed to say: this light contains so much red, &c., forming together a luminous intensity of so much. The labours of M. Chevreuil, and the curious researches of M. Cros have already made an advance in this direction.

But it may be safely affirmed that, in this case as in all others, there will never be any exact measurement until estimation by human perceptive power is eliminated. Man constitutes a detestable measuring instrument. The difference between the impressions of one individual and another, and even between those obtained by the same person at various times, and the difficulty of interpreting the language conveying them, cause the measurements operated directly by man to be altogether wanting in precision. When the question arose of measuring heat (? temperature) men sought for some phenomenon connected with it, and susceptible of some material measurement; expansion fulfilled the necessary condition, and it is by means of this that we are enabled to represent quantities of heat by accurate figures. We shall obtain an exact determination of light only by an analogous process. We shall make use of some phenomenon—chemical decomposition, molecular disaggregation—it is impossible to say what; but some phenomenon measurable in length, in weight, or otherwise, so long as the measure is material and outside of any personal appreciation. Then we shall have well-defined units, and measurements accurate and incontrovertible. Until then, the endeavours of *savants* may supply figures which are eminently useful, but always somewhat vague and subject to question.

ON HIGH ELECTRICAL RESISTANCES.

BY THOMAS T. P. BRUCE WARREN.

In *The Electrician* for July 12 appeared a paper on this subject, taken from the *Phil. Mag*, for March, 1879, by Mr. Hopkinson.

Mr. Phillips's method of obtaining high resistances by means of black lead lines is no doubt very useful, and certainly economical. A megohm in platinum silver wire costs about £80, whereas the black lead resistance could be made for a few pence. In spite of this difference practical electricians have not given much favour to the black lead resistances. I believe lines drawn with hard and well-prepared carbon, freed from impurities, such as may be obtained from gas coke, would be found more stable in their resistances than those obtained with black lead, however good its quality.

Black lead, as met with in commerce, contains only from 40 to 70 per cent. carbon, the difference being made up with oxide of iron, silica, and earthy impurities. It is not difficult to understand that under the action of different battery powers changes may occur through electrolysis.

There is no doubt that the production of high resistances which are perfectly stable, and at a diminished cost, would be hailed as a boon by the practical electrician and physicist. The lines to be perfectly continuous should be obviously drawn on a smooth surface, such as ebonite, ivory, or a film of collodion, a rough surface would certainly be objectionable. Thin films of platinum deposited on ebonite smeared with plumbago could easily be ruled off by means of a proper tool into very fine lines, and by means of a small scraper a high resistance should be easily adjusted to within a little of what may be required, and for the purposes of the electrical student it should be possible to obtain "a set of resistance lines" for a very great deal less than £35, the price of a box of resistance coils.

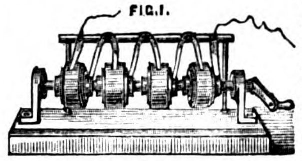
Selenium, as a material for obtaining high resistances, has forced itself upon our notice more from its peculiar behaviour to light than anything else. There is a wide field open for exploration with the other non-metallic elements, and although it may seem disrespecful to question Faraday's classification of insulators, I know that a few of the elements he regarded as insulators would now be looked upon as good conductors. This arises from the fact that we possess much more delicate appliances for examining currents.

PROGRESS AT MENLO PARK.

Mr. Edison, says the *Scientific American*, has wisely kept his own counsels of late, so that very little is known outside of his laboratory as to what goes on within. Occasionally the public gets an idea through the publication of one or two of the scores of patents pending and complete; but these do not indicate the real nature of the improvements that are maturing and soon to be made known.

The electric light and the various matters pertaining to it engross the attention of Mr. Edison and the majority of his assistants; but just at present the electro-chemical or loud-speaking telephone is being made ready for the market. It is a wonderful advance in telephony. It talks as loudly as the natural voice, and repeats the words louder than they were originally uttered at the distant station. As the construction of this curious instrument was described in these columns in detail some time since, it will be unnecessary to repeat the description here. The telephone depends for its results on the varying friction upon a rotating chalk cylinder, of a platinum faced arm attached to the mica diaphragm of the instrument; the variation in friction being due to electro-capillary or electro-chemical action upon the surface of the chalk effected by an undulatory electrical current proceeding from the secondary wire of an induction coil whose primary is in circuit with a carbon transmitter.

FIG. 1.



Mr. Edison discovered some peculiar freaks in the receiving instrument which at first puzzled him; but, on connecting the binding posts of the telephone with a galvanometer, he found to his surprise that the chalk and platinum rubber of the telephone formed a generator of electricity of no mean order, as it equalled in electromotive force a half of a Daniell cell. He therefore arranged four of the chalk cylinders upon a non-conducting shaft, and connected the platinum rubber of one chalk cylinder with the metallic boss of the next, the terminals being a rubber on one end, and a spring touching the metallic boss of the chalk cylinder at the other end. A series of four chalk cylinders thus mounted and connected (as shown in Fig. 1) is equivalent to two Daniell cells, but the power varies somewhat with the speed at which it is rotated. Mr. Edison is investigating the action of this peculiar battery. He finds that its resistance is 1,200 ohms when at rest, and only 50 ohms when in motion. This is for $\frac{1}{8}$ inch metallic surface on the rubber. When this surface is increased to $1\frac{1}{2}$ inch the resistance will be reduced to 1 ohm. Whether the current is due to the decomposition of the solution with which the chalk is moistened, or whether it is due to capillarity or some other cause, has not been definitely determined. Mr. Edison, in speaking of the electric light, says with a great deal of emphasis, that the system of lighting by incandescence is correct theoretically and practically. It is being perfected in detail, and will before long be exhibited to the public. It would seem from what is at present being done in the Menlo Park laboratory that there are hundreds of points in the problem of electric lighting that have not been considered by experimenters; among these are the proper treatment of the metal or mineral to be subjected to the intense heat required to bring it to incandescence; the insulation and protection of the electrical conductors; the meter for the measurement of the current; and the generator of electricity, which is, after all, the most vital point in the system. Much of the detail of the system has been perfected. The machine which is to supply the current has been completed, and is now undergoing a series of tests to determine its efficiency. Ninety-six per cent. of the power applied to the machine is realised in the electric current, and 82 per cent. of the power is made available outside of the machine. This is about double the effective exterior current realised by other machines. We hope to give our readers a description of the generator as soon as the tests are completed.

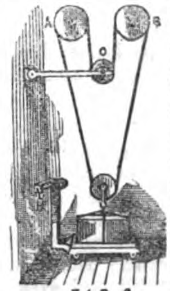


FIG. 2

In endeavouring to measure the power required to drive the generator, Mr. Edison has tried every dynamometer within reach, and condemned them all. At last, after considerable experiment, he hit upon the simple contrivance shown in Fig. 2. He claims that with this apparatus he can measure the $\frac{1}{100}$ of a horse-power. The weighted box rests on the platform scale, and is provided with a pulley for receiving the driving belt, which passes over the driving pulley, A, under the tightener, C, and over the driven pulley B. The number of foot pounds of power used will be indicated by the lifting of the box and the consequent lightening of the load on the scale. Five per cent. is deducted for the angle of the belt and for friction.

Mr. Edison's dynamometer is certainly very simple and effective, but it is in principle something like other dynamometers, employing a weight as a measure of power.

As an evidence of the faith of Mr. Edison and his colleagues in the system of lighting by incandescence, we mention the fact

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that they have prospectors searching for platinum in all the mining regions of the country.

Mr. Edison is confident that the metal exists in large quantities in this country, and he has sent out circulars which read as follows:—

"From the Laboratory of T. A. Edison,
"Menlo Park, N.J., USA.

"DEAR SIR: Would you be so kind as to inform me if the metal platinum occurs in your neighbourhood? This metal, as a rule, is found in scales associated with free gold, generally in placers.

"If there is any in your vicinity, or if you can gain information from experienced miners as to the localities where it can be found, and will forward such information to my address, I will consider it a special favour, as I shall require large quantities in my new system of electric lighting.

"An early reply to this circular will be greatly appreciated.
"Very truly, THOMAS A. EDISON.
"Menlo Park, N.J."

Specimens of platinum and iridosmine sprinkled upon a card were sent with these circulars. The difference in the metals is easily detected with a miscroscope or magnifying glass.

Many replies, enclosing samples of platinum, have already been received at Menlo Park, and the metal has been found *in situ* in two places. Mr. Edison has a stamp mill and all the apparatus required for reducing ores of various kinds. His facilities for reducing refractory ores and metals are particularly good.

INTERNATIONAL TELEGRAPH CONFERENCE.

ADDRESS TO THE DELEGATES AT THEIR FINAL SITTING, JULY 28, 1879.

The Postmaster-General, Lord John Manners, took the President's chair, and gave, in French, an address, of which the following is a translation:—

"Gentlemen and Friends,

"As, on the occasion of the first sitting, I took for a few minutes the presidential chair, so I again do so for a few minutes at the conclusion of your labours, in order to bid you farewell. On the former occasion I announced by anticipation the happy results of your deliberations, and I can now affirm that my hopes have been realised. In regard to the European tariff, I know that a tariff per word has been established with a *surtaxe* which does not destroy the simplicity of this method of charge. Moreover, England can, I believe, free herself from this *surtaxe*, and thus enjoy a pure and simple tariff per word.

"There has been a tolerably equitable reduction in the European tariff. As to the extra-European tariff, no observation is called for. But in the aggregate the result of your labours will be a considerable progress for international telegraphy. It is to your assiduity, gentlemen delegates, and to the mutual concessions which you have seen your way to make, that this happy result is to be attributed. I thank you heartily for the co-operation you have given to the London Conference, and I believe I may predict for it a decided success.

"I hope, on the other hand, that you have been able to mingle recreation with work, and that you may have seen things of interest and beauty in England and Scotland. I have now, in declaring the Conference ended, only to express the wish that you may have a good return voyage to your homes, and that you may all happily meet again at Berlin in 1884."

M. de Lüders replied to Lord John Manners in the following terms:—

"My Lord: When you did us the honour to open the sittings of the London Conference, you were good enough to advise us not to omit the association of recreation with work. In regard to the work, we have endeavoured to do our best; and we have decided upon those solutions which appeared to us most advantageous. It must be left to the future to decide whether we have accomplished what was expected of us. As to the recreations, those which have been offered us have been so numerous, so rich, so splendid, and so interesting, that words fail me to express the feelings of gratitude we all experience. Besides the pleasant recollections they leave to us, they will also have had the important result of enabling us to know and to appreciate the numerous qualities which distinguish the British nation—industry, activity, the deep sentiment for religion and for home —all qualities which command esteem and sympathy, and which are of a nature to strengthen the bonds of friendship which already attached us to that nation. Once again, my lord, in the name of all my colleagues, receive our warmest thanks for the reception which has been given us."

The minutes of the last sitting were read and passed, but before they were brought to a close M. d'Amico desired to insert in them a word of thanks, in the name of the Conference, for the assistance rendered by the *Bureau International*, and for the active and intelligent part taken by M. Curchod and M. de St. Martial in their labours.

C. H. B. PATEY, President.

VISIT OF THE DELEGATES TO THE WORKS OF MESSRS. R. JOHNSON AND NEPHEW, MANCHESTER.

During the visit of the Delegates to the North they were invited to visit these ironworks. The visit was made on July 24th. The works are complete of their kind, and the Delegates were shown various operations of a most interesting character in connection with iron manufacture. Having first seen the process of puddling and rolling the iron into bars, the drawing of telegraph wire was shown. Bars heated in a Siemens gas furnace were rolled in a continuous mill to No. 4 wire rods. This continuous operation was first carried out at these works, and is a speciality with the Messrs. Johnson. By means of it ¼in. rods, weighing 140lbs. or more, are produced in one operation. These rods are then drawn down into telegraph wire of unusually long lengths. The shops were next visited, in which were being carried out the processes of cleaning, drawing, annealing, and galvanising the wire. A very careful series of tests is made in the works to obtain the exact values of the wire made as regards tension, elongation, torsion, and conductivity. Other interesting portions of the works were seen, and the visitors expressed their surprise at the completeness and compactness of the whole.

The following gentlemen sat down to an excellent luncheon provided by the proprietors of the works:—

Mr. Johnson, Madame de St. Martial, General de Lüders, Mr. Pender, M.P.; M. le Commandeur D'Amico, Mr. Beaufort, M. Vinchent, Mr. B. Armitage, Mayor of Salford, Mr. Patey, Madame do Rego, Mr. Preece, Colonel Shaw, U.S. Consul; M. Salmonovitch, M. Akerlund, Mr. Salmond, Mr. C. Goldstone, Mr. Tunbridge, Mr. Warburton, Mr. Beresford, Mr. Ford, Mr. Dinham, Mr. Neale, Mr. Morton, Mr. Bottomley, Mr. Wells, Mr. Woodhouse, Mr. C. V. Walker, F.R.S.; Mr. J. P. Bedson, Mr. Langdon, Mr. A. Graves, M. Gerhardi, Mr. Borring, Mr. Fletcher, Mr. Fish, Mr. Eaton, Mr. W. H. Johnson, Mr. Radcliffe, Mr. Woods, *Courier*, M. le Docteur Brunner de Wattenwyl, Mr. Baines, Mr. J. Galloway, M. Yoshikawa Akimasa, M. Richard, Etienne Musurus Bey, M. Gibbs, Mr. Spagnoletti, Mr. S. Armitage, Rev. J. Coghlan, *Guardian*, Mr. Pettifor, Mr. Morris, Mr. Ansell, Mr. J. C. Edwards, Mr. Bell, M. Radoykovitch, M. Nordlander, Mr. E. Graves, M. Staring, Mr. Shuter, Mr. Thewlis Johnson, Sir James Anderson, M. Honke, M. Robescu, M. Hirayama, Mr. Blewitt, Mr. C. F. Varley, Mr. Evans, Mr. Reid, Mr. Lowe, Mr. Laker, *The Times*, Mr. Clegg Livesey, Sir C. Bright, M. Eschbaecher, Mr. Winter, M. Nielsen, M. Pissarewski, Guildani Effendi, M. Curchod, M. Gibbs, jun.; M. Munchiro Nakano, *Examiner*, Mr. E. M'Grath, Mr. Clapham, Mr. J. M. Norman, Mr. Doherty, M. Granfeld, Mr. Benton, M. Bugge, M. F. de Otin, M. Do Rego, Mr. Bergmann, M. Frey, M. Kara, Le Chevalier Berliri, Major Wood, Mr. J. C. Johnson, Mr. Walsh, Mr. Talbot, Mr. Wilson, Mr. Crozier, Mr. Temple, M. de St. Martial, M. le Camus, Mr. Branscombe, Mr. Stearns, Mr. Oppenheimer, M. Koller de Granzow.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).

The half-yearly general meeting of this Company was held at the Cannon-street Hotel on Tuesday, the 5th August, "for the purpose of obtaining the sanction of the Company to the payment of an interim dividend." Mr. Henderson presided. A circular, accompanying the notice convening the meeting, stated that after deducting the usual depreciation on buildings and machinery, the net profit made by the Company in the six months ending the 30th of June was £18,800. Of this sum the Directors propose to distribute an interim dividend for the half-year of 10s. per share, free of income tax, being at the rate of 10 per cent. per annum, payable on the 6th of August. This would absorb £15,600, and leave £3,200 to be added to the £9,049 brought forward on 31st December last, making the balance to be carried forward £12,249. The paid-up capital of the Company was now £312,000, the 3,000 unissued shares having been sold last March in the open market.

Mr. W. TYLER, the Secretary, having read the notice convening the meeting,

The CHAIRMAN said: We have requested you to meet us to-day in order that we may obtain your permission to pay an interim dividend, which from the state of the accounts we have much pleasure in recommending. The

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business of the Company for the past half year has been fairly good—perhaps better than we could expect, considering the great depression which continues throughout the country. Every article we manufacture has felt this depression. Even those the sale of which has hitherto increased during wet weather have been sparingly bought, showing that people have not money to spend, and are making their old things last longer than usual [laughter]. In our cable department we have been better employed than of late years, and this has to some extent made up for the decline in our general sales. The price of india rubber advanced very much a few months ago, but, thanks to the foresight of our manager, we held a considerable stock bought at low prices. I have now merely to move that an interim dividend of 10s. per share, free of income-tax, being at the rate of 10 per cent. per annum, payable to-morrow, be now declared [cheers].

Mr. SILVER seconded the motion, which was carried unanimously.

On the motion of Mr. DAVID SMALL, who thought that the dividend was very satisfactory, a vote of thanks to the Chairman and Directors was passed, and the proceedings terminated.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

The fourth ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on Friday, August 1, 1879, John Pender, Esq., in the chair.

The SECRETARY read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, you have had the report in your hands for some days, and therefore, I presume, you will take it as read. Gentlemen, I shall, as usual, refer to one or two points in the report, so that, clear as it is, I may probably make it still more clear. As stated in the report, the Company's revenue for the half year under review, after deducting rent of landlines and payment to Anglo-Company, amounted to £87,706 3s. 2d., and the working and other expenses (exclusive of cost of repairs, interest on loan, and income tax, &c.), absorb £20,523 5s. 10d., leaving a balance of £67,182 17s. 4d. as the net profit for the half year, making, with £5,273 8s. 4d. brought from the previous half year, a total of £72,456 5s. 8d., which has been appropriated as follows: — An interim dividend of 5s. per share for the quarter ending 31st March last has been paid, and a final distribution of like amount for the June quarter is now proposed, amounting together to £30,355, and making, with previous dividends, a total of 5 per cent. for the year. A sum of £34,765 4s. 3d. has been carried to the reserve fund, which, after being charged with £8,965 9s. 11d. for cost of repairs, now amounts to £100,000. An amount of £5,000 has been written off the arbitration and liquidation expenditure, and the balance of £2,345 1s. 5d. is carried forward. Our revenue for the half year, as compared with that in the corresponding period of 1878 has increased nearly ten per cent., while our total expenditure has slightly diminished. The result of this is an increase in our net revenue equal to 16 per cent. per annum. Every economy has been exercised in our working charges at home and abroad, as shown in abstracts "A" and "B," which, taken together, are 11 per cent. less than in the same period last year, and although this reduction is about counterbalanced by special expenditure, the saving in this direction should, nevertheless, not be overlooked. The repairs of the Company's main and short cables, which, with favourable weather, might have been effected in a few days, were unfortunately delayed by continued gales and fogs, and the cost was proportionately increased, the total sum expended having amounted to £8,965 9s. 11d. Referring to the balance-sheet, it will be seen that the interests of the dissentient shareholders have been purchased at a cost of £56,309, and the 7 per cent. debentures of the old company have been redeemed for the sum of £17,300, requiring together an amount of £73,609. To provide for these and other payments, 5 per cent. debentures were offered to the shareholders in March last; but the subscriptions for them being insufficient, no allotment was made, and it consequently became necessary to obtain a temporary advance of £50,000 to enable the Company to fulfil its obligations. Thus, at a cost of £73,609 shares and debentures to the nominal value of £93,560 have been purchased, and the Company's liabilities on capital account to that extent reduced. The new Company having now been in existence two years, a brief comparison of its working and progress during that period may not be uninteresting. Our revenue for the financial year just closed amounted to £177,649, against £164,070 in the year ending June, 1878, showing an increase of £13,579, which is equal to more than 8 per cent. On the other hand, our expenditure for the year just closed amounted to £51,237, against £54,772 in the year ending June, 1878, showing a reduction of £3,535, equal to nearly 6½ per cent. The result in net revenue is an increase of £17,114, or 15¾ per cent. in favour of the financial year just ended. Having put before you this very plain and, I hope, satisfactory statement of the last year's revenue, I have now to make a few remarks which are perhaps better spoken from this chair than embodied in a directors' report. The expenses, though apparently larger than before, are in reality less. This is caused by the difficulties we have found in getting rid of the great incubus which was fixed on this Company at its formation, and I am afraid that these difficulties are not yet at an end. When the old Direct Company was formed it was essentially a contractor's company, and for four years they were the only parties who got any benefit out of the company. The contractors, or those who were more or less connected with them, hung upon the company till the last moment. The result was that we had an arbitration suit as to the value of the shares, and we thus incurred an enormous waste of money. I believe, in one way and another, with costs and the difference in the value of the shares, the arbitration cost this Company £21,000. If I were to express an opinion after the experience of this arbitration, it would be, have nothing to do with arbitrators or arbitrations, but rather trust to a court of law, and the less of that the better. But, gentlemen, it was not in our option. The arbitration was forced upon us, and I believe even those who forced it upon us would have had as much money in their pockets if the arbitration had not taken place, and they had accepted the amount we offered them for the shares, as they received at the end of the arbitration. Therefore, I consider the amount that was expended through that arbitration was simply thrown away. As I have said, we have not yet got rid of this parasite, which has clung with such tenacity and has done so much injury to submarine telegraphic enterprise. The parties who were mainly interested in forming the old Direct Company did so at a cost of something like £300,000 to the shareholders more than it should have cost, and, as I am informed, so rapid was the decline in the value of the shares after the formation of the company that even those who had anticipated getting a large profit out of it found that it would have been better if they had never touched it. This remark applies more particularly to the syndicate which was formed to float the company, and sustained a loss of about half a million of money. When I last had the pleasure of addressing you I referred to a competing company which was then in the course of formation. The contractors who made the Direct Cable found it impossible to raise the money in England for another Trans-Atlantic Cable, as the existing company's stock was at 50 per cent. discount; but, showing their usual energy and enterprise, and taking advantage of a period of financial excitement in France, they were fortunate in being able to form another syndicate there, and a company has been floated with a capital of something like two millions sterling. I need not say that there is a large margin in this sum for the promoters of the company; but I suspect that before the game is fully played out, this combination will find themselves in much the same position as did the syndicate for the old Direct Company, that is, that their property will be at a discount of 50 per cent. before twelve months have passed over. I am not blind to the fact, however, that to bring about this result it will cost us some money; but we must do our best when we find our property attacked, and attacked in a way which I must say is not quite in conformity with a strict business mode of dealing. I think that to go over to France, and take advantage of, I may say to a certain extent the ignorance of the people, and put before them shares which they could buy in England for half the price they were asking, is scarcely consistent with our idea of fair dealing with the general public, and that at a time when there is no public demand for additional telegraphic communication. It is our duty, therefore, to protect our shareholders, and I trust this will be the last attempt they will be able to make to interfere with Submarine Telegraph Companies. When competition is desirable there is no one who will hail it with more delight than I will. I repeat now what I said to some of the heads of the financial establishments in France who are carrying out this project:—that it was an unfair thing to the French people to invite subscriptions for an enterprise, which, as I have said before, was in England at a great discount. While on this subject I will make a further remark, and that is that submarine telegraph property is to say the least of it a novelty, while it has at the same time become a great public necessity. We have yet to learn a great deal about submarine telegraphs, for instance, as to the length of the life of a cable, and, therefore, we ought to be prepared; and I think we have shown that we are preparing by the way in which we have accumulated our reserve fund, and will go on accumulating it. Until we know something more of the life of the telegraph cable than we know at present we must be prudent and cautious in dealing with it. Should telegraphs become discredited in the eyes of the public, and should the cables fail and the public be disinclined to subscribe for further cables, the duty to find them must devolve upon the governments. If governments, therefore, wish to avoid this great responsibility they must show greater consideration than they have hitherto done for the existing submarine telegraph companies. All the governments acknowledge the great benefits which they have derived, and are deriving, from the companies; but I am afraid they do not take the broad view which they ought to take in regard to their maintenance, for they seem only too ready to grant any one concessions from which they fancy they may receive a temporary benefit, forgetting that such a policy may eventually involve them in serious outlay. I think the result of this new French cable, worked as it is likely to be by the same elements that controlled the old Direct Company will practically have the same result as befel that company, namely, that there will be no dividend for the shareholders for some years, and probably at last it will be rescued from their hands, as the Direct Company was. Before I meet you again, therefore, we may be engaged in active competition—that is, if they succeed in laying a cable. If I were to believe some of the newspaper paragraphs, I should doubt, even now, although a portion of that cable is laid whether the money has been found for completing it; but I should think that the thing would not be commenced if they did not see a fair prospect of its being completed. Therefore I assume that it will be completed; and, consequently, the completion of it we must meet. I need only tell you that we are fully prepared to meet that competition, and I think I may say that when we make up our minds to fight we make up our minds to win, and the result I hope will be that the present Atlantic companies will be placed on a sounder and better basis than they have hitherto enjoyed, and that the public will enjoy all the benefit of telegraphy to which they are fairly entitled. When I last had the pleasure of addressing you I mentioned that we proposed to issue debentures at 5 per cent. interest, and that the shareholders would have the first offer. We offered those debentures at 5 per cent., and gave the shareholders the opportunity of taking them up; but there was quite an inadequate response. We have now resolved to make a debenture issue at 6 per cent., as many say to us that other cable companies offer 6 per cent. Preference Shares, such as the Eastern 6 per cent. Preference Shares, and the Globe 6 per cent. Preference Shares. We have decided to adopt a similar rate of interest. I may say that in those companies both those classes of shares are at a premium at the present moment. These debentures we propose to offer to our shareholders at that rate. If the shareholders do not take them up we shall offer any balance to the public. As the proprietors may be aware, our cable has been several times injured on Brown's Bank, a locality where extensive fishing is carried on. Our cable has almost invariably been injured by the fishermen dropping their anchors and hooking it. We have issued a notice which we believe will be largely beneficial to us, to the effect that when fishermen pick up our cable and see that they must either cut it or lose their anchors, we shall, in the latter case, compensate them for their loss; they are put to a certain extent upon their honour in this matter, and I believe the result will be more satisfactory to the Company in the future than it has been in the past. Gentlemen, before putting the resolution for the adoption of the report, which I will ask you to approve, I am prepared to receive any remarks which any shareholder

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may choose to make. The resolution is :—"That the report of the directors, dated 18th July, 1879, together with the statement of accounts to the 30th June, 1879, annexed thereto, be received and adopted, and that a final dividend be now declared of 5s. per share, free of income tax, making with the interim dividends already paid, a total dividend of 5 per cent. for the year ending 30th June, 1879."

Lord HAWKE : I beg to second the resolution.

In reply to Mr. Jackson, Mr. Newton, and Mr. John Varley,

The CHAIRMAN said : I am very much disposed to take a similar view to that which Mr. Jackson takes, but at the same time I do not think that this is quite the time to do it. I think by the time this question of competition is settled we shall see our way much more clearly than we do at the present time. If we are to fight I think it as well to have powder for fighting with. Therefore, I think it would be better in the meantime to allow the thing to stand as it is, but if I saw another £100,000 in our reserve fund I certainly would be very much disposed to recommend the Board to adopt Mr. Jackson's suggestion, namely, pay off our debts, reduce our capital, and start with some money in our till. I think Mr. Jackson will probably endorse the view that I take. I approve of the suggestion, and I think when the proper time comes that it is a suggestion which will have very great weight with the Board. What Mr. Newton says in confirmation is quite right. It is true we have invested in what is only giving us 4 per cent., and we are going to pay 6 per cent. on our debentures, and therefore the difference is very considerable ; but, at the same time, we must be prepared to meet any accident or any break taking place. We must have some money in hand, so as to be prepared to deal with a contingency like that if it is required; but the moment we are safe, that will not be required. I may tell you that in another company over which I have the honour to preside, what Mr. Jackson has suggested was carried out, and there we wiped off a great deal of debt by applying a certain amount of the reserve fund. Therefore, I may say to Mr. Jackson that, while we are going for this £100,000 on debentures, we are at the same time wiping off a certain amount of shares ; on the one hand we are reducing, while we are increasing on the other. Therefore, the difference is not the £6,000 which you point out as interest in this account, because you must pay off the debentures, and the £50,000 which we have paid the dissentient shareholders. We have got their shares, and therefore we hold as against that a very large difference.

Mr. NEWTON : May I inquire in what time will the debentures be paid off?

The CHAIRMAN : I am rather suggesting making them as short as we can possibly make them ; but I may tell you that I would almost rather that we did wait for a little time to see the result of the competition, if competition there is to be. With regard to Mr. Varley's remarks about the subscription to the Conference, I dare say you are not aware that this Conference is a body of representatives from the different governments of Europe. They meet for the purpose of establishing rules for international telegraphy. Telegraphy has now become so extended that no one country can deal with telegraphy as a section. It is a question that must be dealt with as a whole, and this Conference deals with it as a whole. We have not been able, nor is it desirable that we should have any vote at these conferences. We send our delegates, but we send our delegates very much on the principle that is done in America, really to obtain counsel more than anything else, and to make them aware of the submarine telegraph wants, or if there is anything said which might interfere with telegraph property to enable those gentlemen to explain so as to satisfy them that they are imposing on submarine telegraphy rules, which would not be at all in their interest, and which would tend very much to retard submarine telegraph enterprise. The result has been that up to this time at the different Conferences which have been held I believe the submarine telegraphs have gained immensely in strength from the opinion which is now held by the different governments of Europe in regard to submarine telegraphs. They are treated now as a very important link, in fact, as a great link and they consider them accordingly. When I mention to you that now there is close upon twenty-five millions of money invested in submarine telegraphs, and that is quite a third of the whole of the cost of land line telegraphs throughout the world, that would give you some idea of the importance of submarine telegraphs. All the different submarine telegraph companies pay an amount so as to enable the companies to receive those delegates and show them attention, and point out to them something of the country in return for the courtesy which was extended to the deputation from this country when they went abroad. I think, after all, that that is money well spent. I am strongly of that opinion. As that is a thing which, as it only comes once in five years, after all it is not a very serious consideration, and I am of opinion that we get very good value for our money.

Mr. JOHN VARLEY : My point is, is it fairly to be expected as the result of this Conference that we shall get protection for our tariff?

The CHAIRMAN : Submarine telegraphs are considered as a whole. I think you will see that at the present moment for us to ask the Conference to pass any law which would make our tariffs fixed would be taking the very weapon out of our hands which we intend to wield in the competition we are likely to meet with. Therefore, we must not ask that Conference to bind us hard and fast in regard to tariffs. That we will take care of ourselves. We do not want them to interfere with us. We want to make our own tariffs. All we want is, that when we come in connection with those landlines that we get the full benefit from them of the proportion of the traffic which is passing over those different lines.

The resolution for the adoption of the report was then put and carried unanimously.

On the motion of Mr. Jackson, seconded by Mr. Wells, the auditors (Mr. J. G. Griffiths and Mr. J. Sawyer), were re-elected.

A cordial vote of thanks to the Chairman and Directors terminated the proceedings.

RECENT PATENTS.

4074. INDEFINITELY DIVIDING ELECTRIC CURRENTS. *A. Arnaud.—Dated 14th October*, 1878, (*Void.*) 2*d*.

One conductor is in direct communication with the positive pole of the battery, and the other is also in communication with this pole by the intermediacy of the work to be executed by each of the sections of the circuit. The current thus passes from the positive conductor through the work to the end of the second conductor, which is in direct communciation with the negative pole of the battery.

4456. APPARATUS FOR PRODUCING, MAINTAINING, AND SUBDIVIDING ELECTRIC LIGHT, *F. H. W. Higgins.—Dated 4th November*, 1878. 6*d*.

A carbon stick placed in a hollow tube is caused to rise by means of a mercury bath in which the tube is plunged, and so bring the upper end in contact with a plate of somewhat highly resistant carbon. The current flows from the vessel containing the mercury through the carbon stick to the carbon plate.

4462. PRODUCTION OF ELECTRIC LIGHT, *H. L. Thomson.—Dated 5th November*, 1878.—(*Not proceeded with.*) 2*d*.

In order to divide the electric current so as to enable several lamps to be worked by the same current, such current is sent alternately to each of the lamps in succession for a very brief interval of time, so that each lamp receives the current a sufficient number of times per second to render the light produced by it apparently continuous.

4464. APPLYING RAILWAY BRAKES, *F. B. Bulkeley.—Dated 5th November*, 1878.—(*Not proceeded with.*) 2*d*.

An electrical generator placed near the engine sends a current through a conductor from one end of the train to the other, and by means of electro-magnets and armatures the brake blocks are applied.

4466. DISTRIBUTING ELECTRICITY FOR THE PRODUCTION OF ELECTRIC LIGHTS, *C. Stewart.—Dated 5th November*, 1878. 6*d*.

The apparatus consists of a commutator, comprising an arm rotating rapidly round and pressing tightly on a disc, on the face of which are placed a number of metallic contact pieces equal in number to the lights to be produced. The wire of the electric machine at the central station is in electric connection with the arm of the commutator through the axis on which it rotates.

4473. APPARATUS FOR OBTAINING ELECTRIC LIGHT, *F. Gye.—Dated 5th November*, 1878.—(*Not proceeded with.*) 2*d*.

One of the electrodes consists of a disc of carbon made to revolve at the same time that it is moved vertically, and the other is an ordinary carbon stick held stationary at a slight distance from the face of the disc.

4476. ELECTRIC LIGHTING, *G. R. Bodmer.—Dated 5th November*, 1878.—(*Not proceeded with.*) 6*d*.

A revolving disc in connection with the source of electricity bears a stud, which presses against the interior surface of a ring to which a number of wires forming different circuits are attached, thus dividing the current as required. An electric lamp is described in which a number of candles are attached to a disc, and as one candle is consumed the disc is partly rotated so as to bring the next candle in position, the disc being prevented from turning until each candle is consumed by means of a peg on the candle bearing against the disc. A weight or spring actuates the disc.

4502. LIGHTING BY ELECTRICITY, *E. G. Brewer.—Dated 7th November*, 1878.—(*A communication.*) 6*d*.

The light-giving material is employed in the form of cylinders or prisms consisting of finely divided metals, such as platinum, iridium, ruthinium, or other material having a high melting point, mixed with non-conductors such as magnesium or zircon oxides that are with difficulty melted. These are mixed and compressed into the proper form for the light, and rendered luminous and incandescent by the passage of the electric current.

4518. ELECTRO-MOTORS, *W. North.—Dated 7th November*, 1878.—(*Not proceeded with.*) 2*d*.

This consists in the arrangement of the magnets, whereby longer magnets may be employed. In cases where two magnets, consisting altogether of four coils, are mounted on a spindle, the coils would represent the north and south poles alternately, and there would be three neutral or nodal points in the armature ; but if the coils are so connected that the two north poles are adjacent and the two south poles adjacent to each other, there will then be only one nodal point in the armature.

4553. MANUFACTURING CARBONS FOR ELECTRICAL PURPOSES, *M. Gray.—Dated 9th November*, 1878. 4*d*.

Carbon prepared in any approved manner is reduced to powder; this powder is washed in alkaline or acid solutions, and then mixed with sugar, molasses, or other suitable adhesive substance, which will liquefy with heat. The mixture is then moulded in proper shape in a press, and afterwards submitted to a high temperature in order to carbonise the saccharine matter.

4559. MECHANISM, &c., FOR PRODUCING LIGHT AND HEAT BY ELECTRICITY, *C. Davis.—Dated 11th November*, 1878.—(*Not proceeded with.*) 2*d*.

This consists in utilising the power or force exerted or produced by the revolution of traction wheels, axles, and shafts, for the purpose of imparting the desired rotary motion to electric apparatus.

4568. ELECTRIC LIGHT APPARATUS, *J. Mackenzie.—Dated 11th November* 1878.—(*Not proceeded with.*) 2*d*.

The carbon or other electrodes, when arranged side by side, are supported in pipes placed at a short distance apart. Mercury is applied to each of the pipes from an elevated head or reservoir, the mercury being allowed to flow into the pipes through a passage in a cock or valve at a sufficient rate to float the electrodes up to the proper height required as they are consumed.

4696. ELECTRIC TELEGRAPH INSULATORS, *C. E. Crighton.—Dated 19th November*, 1878. 6*d*.

The telegraph wire is supported on the centre of the insulator in lieu of at the side by wire lashings, as at present, and a slot is formed in the insulator to receive the wire, which is retained by a hood or cap screwed on, thus protecting the seat of the wire from damp and wet. A wedge of pottery is employed, which fits the groove, and can be screwed down by the hood tight upon the wire, thus, in cases of fracture, preventing the wire from becoming slack beyond the post where accident happens.

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NOTES.

TELEGRAPH CABLES REPAIRED.—The cable between St. Vincent and Barbadoes, and that between France and Corsica, are now repaired.

TELEGRAPHIC EXTENSION.—Telegraphic communication has now been established with Malacca, as also with Upper Egypt by the Eastern Telegraph Company's system.

SUBMARINE TELEGRAPH COMPANY.—The directors of this Company, in their half-yearly report, state that the result enables them to add the usual proportion of receipts to the reserve fund and recommend a dividend at the rate of 17½ per cent. The dividend for the corresponding period was at the rate of 17 per cent. The reserve fund now stands at £67,563.

MEMORIAL OF GENERAL ROBINSON.—Some four hundred members of the Telegraph Department recently subscribed towards a memorial of Major-General Robinson, late Director-General of Telegraphs of India. A bust of General Robinson, which is said to be a capital likeness, was purchased with the money subscribed, and has been placed in the public entrance of the Telegraph Office, Dalhousie-square, Calcutta.

TELEGRAPH APPARATUS.—We notice, for the benefit of such of our readers as are interested in the appliances of telegraphy, that the German and French authorities are now seeking tenders for large quantities of telegraph material. The details of the contract are given in our contemporary, *The Contract Journal*, a new publication, specially devoted to the tabulation and classification of all contracts open in the English and Continental markets.

THE CAPE CABLE.—The *Natal Mercury* of July 14th, contains the following:—"The steamship Kangaroo left here on Thursday last for Delagoa Bay, to which place she will pay out the ocean cable. She picked up the buoyed end at the outer anchorage without any difficulty. At Delagoa Bay she will meet the Seine, which is also engaged in laying a portion of the same cable. A telegram through the new cable states that the Kangaroo arrived at Delagoa Bay on Sunday."

SOUTH AFRICAN COLONIES TELEGRAPHIC COMMUNICATION.—In the House of Commons, on August 12, Sir H. Selwin-Ibbetson moved that the contract dated the 9th of May, 1879, entered into by the Lords Commissioners of Her Majesty's Treasury with the Telegraph Construction and Maintenance and Eastern Telegraph Companies for establishing telegraphic communication with the South African Colonies be approved. In answer to Major Nolan, Sir H. Selwin-Ibbetson said that the contract was for £5,000 a year, contingent on the working of the line. The motion was agreed to.—*Times*. [It is evident that the reporter of *The Times* did not fully catch the words of Sir H. Selwin-Ibbetson, the contract being for £35,000 a year, not £5,000, as in the above report.]

THE EDISON TELEPHONE COMPANY OF LONDON (LIMITED).—The capital of the Company is £200,000 in shares of £100. Formed to adopt and carry into effect an agreement made between T. A. Edison and the Right Hon. E. Pleydell Bouverie and others. To acquire any letters patent, rights, or monopoly, relating to the inventions mentioned in the agreement, and to manufacture, sell, license, and let apparatus for the application of the said inventions. The subscribers are: E. P. Bouverie, 44, Wilton-crescent, 10; S. R. Scott, 75, Old Broad-street, 5; W. Campbell, 18, Old Broad-street, 5; John Lubbock, 15, Lombard-street, 5; G. Richardson. 3, Lombard-court, 5; A. Howell, 30, Eastcheap, 5; G. E. Gouraud, 6, Lombard-street, 10. The directors shall be G. E. Gouraud, E. P. Bouverie, Viscount Anson, W. Fowler, and Sir Philip E. Woodhouse, K.C.B.; remuneration, £600, qualification of each director, £500.

PHYSIOLOGICAL EFFECTS ACCOMPANYING METEOROLOGICAL PHENOMENA.—*Le Journal d'Hygiène* publishes a lengthy article, in which the sufferings of certain persons on the approach of rain are attributed to the electrical changes taking place in the atmosphere. The case is cited of a retired captain, whose leg had been amputated, and who patiently noted the periods of the recurrence of pains due to the irritability of the severed nerves, and the coincidences between these periods and the atmospheric distubances registered by the central meteorological office of the United States. He ascertained from his observations that his sufferings were greater when rain was about to fall than when it was actually falling; and he claimed that he could thus predict and give the time of the occurrence of rain even when the shower did not occur within a distance of some kilometres from his residence. M. de Fonvielle gives another case, that of a female who in her youth had been struck by lightning, and had since suffered from an incurable contraction of the muscles of the neck. Every time rain is about to fall she experiences sharp pains in this region, which become alleviated only when the rain has fallen. It is suggested that, in view of the great sensitiveness of the animal organism as an electroscope, the sensations of such persons should be carefully compared with observations made on the variations and current phenomena of atmospheric electricity.

AFGHANISTAN.—In the recently published papers on Afghanistan we find several references to telegraphic communication. Thus we read that:—"The treaty of Gandamak provides for the immediate commencement of telegraphic communication between Cabul and India. The advantages of such communication are obvious; and the establishment of it will both illustrate and confirm the character of the change now effected in our relations with Afghanistan." And the 13th section of Lord Cranbrook's despatch to the Governor General states that:—"The engagements in regard to the construction of a line of telegraph to Cabul through the Kuram Valley and the improvement of the present imperfect facilities for commercial intercourse between India and Afghanistan which are embodied in Articles 6, 7, and 8 of the treaty are cordially approved by Her Majesty's Government. Although the promises made by Shere Ali to the late Lord Mayo on this subject were never fulfilled, he lived to see the benefit which accrued to his country from the measures agreed upon by your Excellency's Government and the Khan and sirdars of Khelat affecting the lower trade routes between Afghanistan and Beloochistan. The Ameer Yakoob Khan has only to observe the improvement in those regions, in the way both of extended trade and of increased

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civilisation, to appreciate the solid advantages which commercial facilities and improved communications bring in their train."

Fusible Metals.—Under the name fusible metal or fusible alloy is understood a mixture of metals which becomes liquid at temperatures at or below the boiling point of water. There are several such mixtures known, some of which are placed in convenient order as follows:—1. D'Arcet's: Bismuth, 8; lead, 5; tin, 3 parts. This melts below 212°F. 2. Walker's: Bismuth, 8; tin, 4; lead, 5 parts; antimony, 1 part. The metals should be repeatedly melted and poured into drops, until they can be well mixed previous to fusing them together. 3. Onion's: Lead, 3; tin, 2; bismuth, 5 parts. Melts at 197°F. 4. If, to the latter, after removing it from the fire, one part of warm quicksilver be added, it will remain liquid at 170°F., and become a firm solid only at 140°F. 5. Another: Bismuth, 2; lead, 5; tin, 3 parts. Melts in boiling water. Nos. 1, 2, 3, and 5 are used to make toy spoons to surprise children by their melting in hot liquors. A little mercury (as in 4) may be added to lower their melting points. Nos. 1 and 2 are specially adapted for making electrotype moulds. French cliché moulds are made with the alloy No. 2. These alloys are also used to form pencils for writing, also as metal baths in the laboratory, or for soft soldering joints. No. 4 is also used for anatomical njections. Higher temperatures, for metal baths in laboraories, may be obtained by the following mixtures:—1 part ;i and 2 parts lead melt at 441·5°F. 1 part tin and 1 part ead melt at 371·7°F. 2 parts tin and 1 part lead melt at 340°F. 63 parts tin and 37 parts lead melt at 344·7°F.

The Electric Light on the Embankment.—Further experiments with the electric light on the Thames Embankment indicate that the light may be produced at less cost than appeared possible at the time when only 20 lights were in circuit. It will be remembered that the engine employed is of 20 horse-power nominal, manufactured by Messrs. Ransomes, Sims, and Head, and that the Jablochkoff lights are used. Operations were commenced at the end of last year, the engine driving 20 lights, indicating about 23 horse-power, and consuming 3·8lb. of coal per indicated horse-power per hour. Six months afterwards a second Gramme exciter and divider were added for lighting 40 lights, when the engine indicated about 38 horse-power, and the consumption of fuel was about 3·2lb. Last month a lengthened experiment was made, in order to test whether the engine was capable of driving three exciters and three dividers for supplying light to 60 candles through a circuit of nearly a mile and a half, and it was found that with an indicated power of about 60 horses, and making 140 revolutions per minute, the engine was completely master of the work, and the 60 lights burned more steadily than when the smaller number were driven. As the consumption of fuel will not probably exceed 3lb. per indicated horse-power when working 60 lights, and the working charges will be about the same as when the experiments were made upon which Mr. Keates founded his report respecting the cost of 20 lights, it seems evident that the cost of electric lighting may be reduced by existing machinery and appliances to something not greatly in excess of that of gas.

Overtones in the Telephone.—Among the communications to the American Philosophical Society was one by Prof. Frazer, stating that in his use of the local telephone circuit he had observed a continued resonance of overtones. In the course of some experiments on a telephone line, with a view to decrease the crackling due to atmospheric disturbance, an observation was made which will seem to illustrate to what an infinitesimal motion the sounds heard through the telephone are sometimes due. A telephone was selected in which the diaphragm was held fast at only two or three points instead of on a flat surface, which usually binds the outside of the metal plate. The diaphragm gave to one note a clear resonance, in which the overtones so charateristic of metal plates in vibration were distinctly heard (middle A of piano). On sounding this note into the mouthpiece, while keeping the other telephones covered so as not to be directly affected by the air waves, it was found that the overtones were audibly traceable in one of the other telephones with which connection was had over a line of about one-third of a mile, with a ground return circuit. It is difficult enough to understand how the minute waves into which a metal plate is thrown by a vigorous note of the voice can reproduce sound through the intermediate agency of maxima and minima of resistance in the medium of current transmission; but that the minute wavelets which are produced upon the backs of these should, at the extremity of a long line, produce sufficiently powerful variations of conductivity to cause the mechanical fluttering of the diaphragm of another instrument to a sufficient degree to cause the effect of sound could scarcely have been foreseen.

The Electric Light.—Some experiments to try the relative economy and illuminating power of gaslight and the electric light were on Friday conducted in the Picton Reading Room, a large new round building with dome, just completed, between the Brown Library and Museum and the Walker Art Gallery in Liverpool. The building was darkened for the occasion, and a number of town councillors, engineers, and others interested, including the chairman and engineer of the Liverpool Gas Company, attended the experiments. Both the gas company and the British Electric Light Company were afforded facilities for illustrating the illuminating power of their respective agencies. The gas company had erected an extensive temporary arrangement with the object of flooding the large apartment with a bright and steady light, and it is estimated that in their efforts to accomplish this end the gas was consumed at the rate of over 2,000 cubic feet an hour, or a cost of 7s. an hour. The method of illuminating by the electric light originally proposed by the engineer of the British Electric Light Company was by reflection, chiefly from the dome, and the arrangement adopted on Friday of placing the light on a centre pedestal (which is the borough engineer's idea) most effectually carried out this method. The result of the Library and Art Committee's inspection of the rival illuminators was that they determined on the adoption of the electric light. The electricity was generated from the Gramme machines, driven by the engine which supplies the Steble fountain, but which is not suited for the electric light purposes, and is blamed for the unsteadiness still noticeable. As the electric light on Friday only cost about one third the price of the gas illumination, the committee probably see that the economy will soon repay the cost of a suitable engine. If the company achieve the steadiness which their engineer promises, the new light will not only be a great boon to readers, preserving them from a vitiated atmosphere, but it will prove a source of economy in the binding department. Books placed on high shelves suffer very much from the influence of gas, the exposed part of leather bindings being reduced to a powdery substance in a surprisingly short time.

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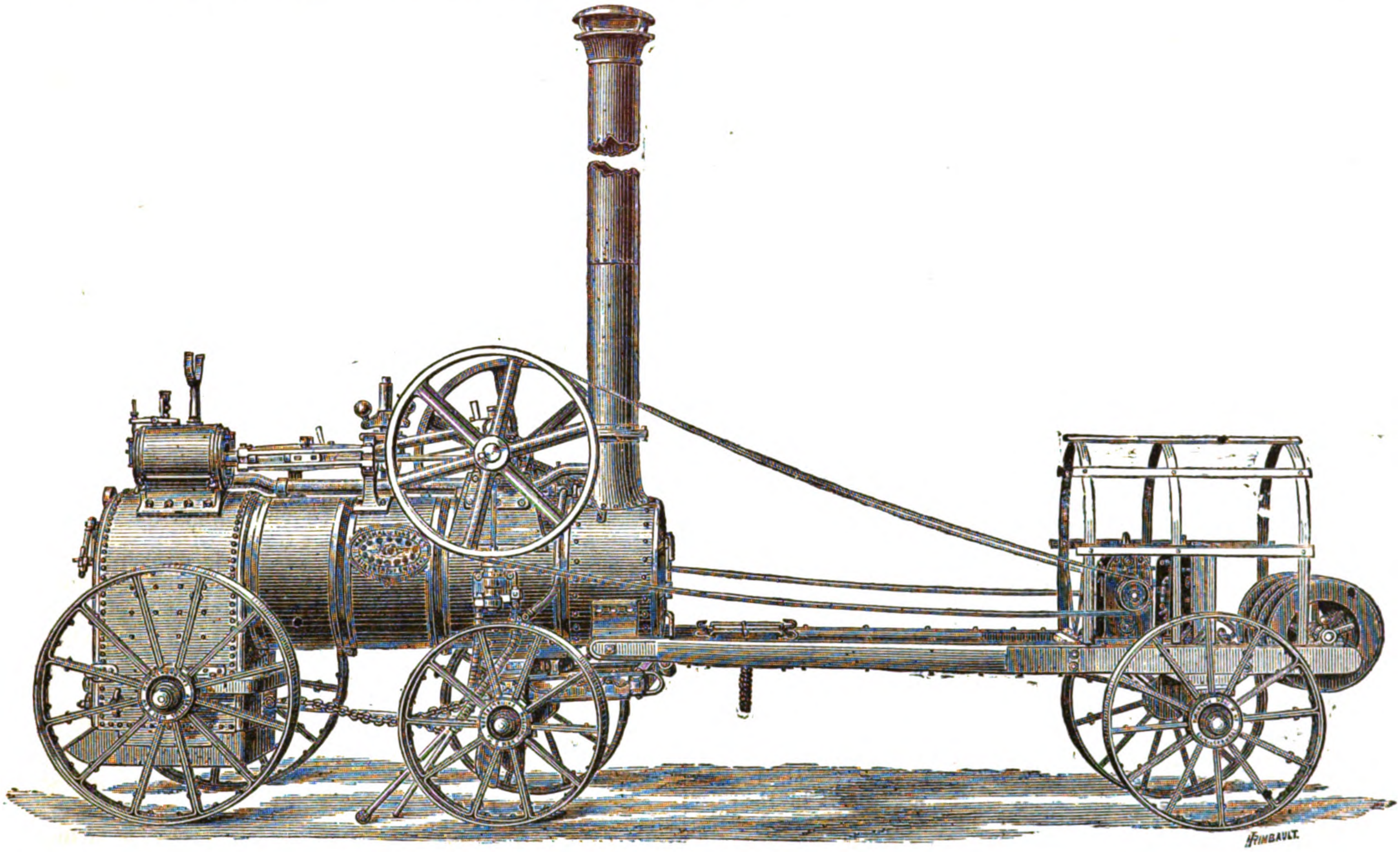
MOTOR POWER FOR ELECTRIC LIGHT.

At the late Kilburn Show of the Royal Agricultural Society Messrs. Marshall, Sons, and Co. exhibited a six horse-power portable engine, to which was affixed a carriage carrying a dynamo-machine. We herewith illustrate this convenient arrangement which has been constructed for contractors and others requiring temporary use of the electric light. We might suggest a use for the light which, this year at any rate, should not be overlooked, viz., for harvesting purposes. The weather has been so changeable that farmers would have recouped again and again the extra cost of working relays of men, those by night working by means of the electric light. The harvest will soon be upon us, and it may be, if the weather does not alter for the better, necessary to cut and carry by night as well as by day when *the* opportunity arrives. Here we have the means. Will advantage be taken of it? The engine illustrated is portable, and of 6 H.P., with steam-jacketted cylinder, 8·5″ diameter 12″ stroke, and two driving pulleys having extra heavy rims. It is fitted with the well-known Hartnell Automatic Expansion-valve gear, controlled by the governor. Experience shows that this gear gives remarkable uniformity of speed under varying loads, and is exceedingly steady and free from any tendency to pulsate or hunt.

The dynamo-machines are bolted on to a strong two-wheeled carriage, or tumbril, the shafts of which also form the distance pieces for connecting it to the smoke-box end of engine, this tumbril also carries the drums, bearing 300 yards of cable coiled on them, commutator for switching the current off and on to the lamps, or from either machine to either lamp, tools, lamp boxes, &c. The whole is covered by a light tilt cover of tarpaulin for protection from the weather. The engine can be put down, machines and lamps coupled up, and a light shown in one hour.



THE ELECTRO-CALCIC LIGHT.

We have at various times casually referred to this system patented by Mr. Wentworth Lascelles Scott, but have hitherto refrained from describing it fully, inasmuch as premature descriptions frequently vitiate patent rights. We think, however, that, as the inventor's specification is now published, there can be no objection to publicity. The inventor is the first, so far as we are aware, to use condensers in connection with electric lighting. We are quite aware that condensers have been used in more than one system devised to light gas lamps by means of electricity, so as to avoid the necessity of the lamplighter going to every lamp. The author uses a condenser or condensers of suitable construction, the surfaces of such condensers being equivalent to one-and-a-quarter times (or thereabouts) the surface of the conducting wires, plus such additional length of the same wire as may be of equal resistance to the resistance of the burner. Why such resistance is taken we do not know. It would be interesting to see the calculation which leads to the selection of this ratio. The condensers used can be of the ordinary pattern, but preferably should be of a kind devised by Mr. Scott, and termed by him "augmentors," or "magnetic condensers." He thus describes his system:—

"These 'augmentors' or 'magnetic condensers' I construct in a similar manner to the condensers hereinbefore described, except that between the metallic plates or layers thereof I place a layer or stratum of iron (or other magnetic metal) in the form of plate, sheet, foil, wire, or powder, such iron layer or stratum being insulated by a coating or covering of any suitable material, and being carefully guarded against all contact or electrical connection with the conductive surfaces, on either side thereof. I prefer for this purpose to employ iron wires placed transversely or at right angles to the edge of the said conductive layers or bands. Such conductive layers, plates, bands, or ribbons I prefer to construct of sheet copper coated superficially with silver, nickel, or tin, but I do not confine myself to this particular material for such purpose. The said new form of condenser is also available for other purposes for which such instruments are usually employed, and I find it to be greatly superior in its effects to the arrangement hitherto known under that name."

In some instances he replaces the ordinary conducting wires with flat bands or ribbons of metal, of which several are superimposed one over another, a layer of insulating material separating each metallic band from the others (with or without the stratum or layer of insulated iron before mentioned), thus forming a kind of elongated "augmentor" or "condenser," which also serves the purpose of a conducting wire or wires.

He also employs in connection with the augmentors a "secondary battery" which receives any excess or overplus of electricity which may, when a number of lamps are in use simultaneously,

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be set free by the extinguishing of one or more. These he terms reservoir condensers.

The burners employed are made of lime, magnesia, alumina, zirconia fixed against the conducting wires. The conductivity is increased or diminished by coating, impregnating, or mixing in with their substance platinum, iridum, palladium, silver, copper, Tungsten iron, graphite, carbon, or other suitable conductor of electricity; and such metallised and carbonised electro-calcic surfaces and burners are used as terminal points, electrodes, and electro-pyres, from which electric lights are or can be produced or emitted.

He also claims the use of platinum, iridium, palladium, &c., in connection with these burners, and certain fluorescent substances for the purpose of modifying the light obtained, sometimes impregnating the burner with the fluorescent substance; at other times using it in connection with a glass globe.

Another claim is in altering the colour or tint of the light produced from the electro-calcic burners when required for signalling, military, naval, photographic, or other special purposes, by adding such metals or compounds as will impart to the light emitted the desired tint. Thus, if a red light be required, the electro-calcic burner should contain, in addition to its other constituents, a small quantity of some salt or compound of lithium or strontium; if a green light be required, a thallium compound; if yellow, a salt of sodium; &c.

It seems to us that the various uses of mercury in tubes or in streams bear too close a resemblance to the arrangements of Mr. Harrison, and till we have seen a perfect burner where mercury is used we shall always object to its use as being of a very dangerous nature. We have seen Mr. Harrison experimenting with a mercury stream almost the exact counterpart of that described by Mr. Scott. Both Harrison and Scott use mercury as an electrode; other inventors, as well as Mr. Scott, use it as a balance. If the use of mercury could be rendered absolutely safe, then the bias against it would be unavailing; but it is well known that many experimentalists have suffered, and some have been killed, by its use, and that caution is very necessary. Mercury in any shape or form could not be put into the hands of the general public.

COMMERCIAL APPLICATIONS OF ELECTROLYSIS.

BY PAGET HIGGS, C.E., LL.D.

(CONTINUED FROM PAGE 123.)

(*Second Paper.*)

Amongst the sources of current that appear available for electro-metallurgical purposes, is Jablochkoff's carbon battery. M. Jablochkoff set himself the task of designing a battery, in which carbon should be the material consumed. This electrical element consists of an exterior vessel containing nitrate of soda, or nitrate of potash, or common saltpetre. In this salt is embedded an iron crate or cage, containing coke, which, at the starting of the battery, is ignited, preferably at the lower part of the contents of the crate. Combustion of the coke is maintained at the cost of the oxygen of the nitrate, and the resulting products are carbonate and nitrite of the alkali. The cost of the battery is the cost of the coke consumed, plus the difference of values of the nitrate and the resulting salts, and as the latter are produced in a somewhat crude condition, the difference is more than that between the costs of the salts commercially. The writer has ascertained, from a series of experiments with this battery, that its current is remarkably constant, and that it appears very suitable for an electrical source on a large scale, where currents of large quantity and of electromotive force of 0·5 to 3 Bunsen elements are required. Nickel deposits have been very successfully carried out with this battery, because by regulation of the firing, the intensity of the current can be very steadily, yet considerably, changed. Trials are still required to estimate the economy of the arrangement, and to obtain, with greater accuracy, a knowledge of the amount of salt consumed in practice for unit of current developed. Where there are large copper deposits, and where saltpetre is cheap, there are also some chances of this source of electricity becoming practically available.

The next source of current to be considered is that of magneto and dynamo-electric machines. The machines most successfully employed for electro-metallurgical purposes are the Wilde, Gramme, and Weston machines. Of these, the first may be considered as superseded by the latter two as regards economy and initial cost, although the work done by it has been amongst the most valuable rendered to the galvanoplastic art. The Gramme and Weston machines have both been described in these pages, and both are very extensively employed in the depositing of metals on the large scale, the Gramme appearing to meet with favour in depositing copper and silver, and the Weston in nickelling. In Messrs. Christofle's works, 14 Gramme plating machines are kept in pretty constant use, for depositing copper and for silvering; but for gilding, an extension of the battery process appears to be productive of the best results. In the London Nickel Plating Company's vats, all the work is done by one medium sized Weston machine, which has, however, the disadvantage of requiring to be cooled with a stream of water.

Both the Gramme and Weston machines are provided with means of resisting the reflex action of the bath. As is well known, all electrodes immersed in an electrolysed solution acquire a polarity opposite to that of the electrolysing current. This contrary current becomes sometimes so powerful as to cause, with dynamo-electric machines, de-magnetisation and reversal of the magnetic polarity of the machines, so that when these are again started to produce a current the resultant current is of opposite polarity to that previously delivered. Consequences of fatal nature to the bath, and to the work in progress, follow in the train of such a reversal, since it may occur without recognition by the operator until too late to remedy the mischief done. In the Gramme machine, the remedy is sought by causing an electro-magnet to break circuit at the weakening of the current that, theoretically, should take place before the actual reversal. But it has been within the experience of the writer that the reversal has occurred too suddenly to allow time for the falling away of the armature of the electro-magnet, and the consequent breaking of the circuit; as the electro-magnetic arrangement was not polarised, it remained indifferent to the polarity of the current passing through its coils, and the strength of the reversed current being sufficient to maintain hold upon the armature no indication was given, except in the vats, of the fact of the reversal.

In the Weston machine remedy is more decidedly obtained by imparting permanent polarity to the field-magnet cores by adjacent steel plates or permanent magnets, together with a mercurial contact breaker, previously described in this Journal.

In the Brush machine a current circuit is provided around the field-magnets, independent of the bath-circuit, so that while the machine remains in motion reversal is impossible; but this device does not perfectly overcome the difficulty.

Magneto-electric machines are not subject to this change of polarity, as the permanent magnets are, of course, completely out of connection or influence of the electrolytic circuit.

For all these machines, it must be remembered, the statement holds good that the current is not truly continuous like that from a battery, but is a succession of electric discharges of an electromotive force proportional to the length of wire surrounding the core. With machines, as concerns electrolytic work, electromotive force, considered as the capability of effecting chemical decomposition, is commensurable with the length of wire in the helix, or helices in some constructions. Resistance, considered as including all obstacles to be overcome, is that due to the helix, and to the necessary magnetisation of the core. Current has then for its formula,

$$\text{Current} = \frac{E \times \text{No. of demagnetisations}}{\text{Total resistance of circuit}},$$

and this formula is available for all classes of dynamo and magneto-electric machines in which the revolving helix or conductor experiences changes of polarity; but for those machines depending upon unipolar induction it is not necessary that this law should obtain as thus stated.

Before describing these comparatively new machines, it will be, perhaps, convenient to briefly recapitulate the principles upon which they are based, as hitherto this kind of machine has received but little attention. The experiments described are due to Edlund. Imagine a steel magnet in a vertical position, readily set in rotation about its geometric axis, and surrounded by a metallic cylindrical muff, which can likewise turn about the same axis. If the current of a battery be caused to pass into this cylinder, in such manner that one of the electrodes is in contact with it in the vicinity of the poles of the magnet, and the second electrode at a point situated between the two poles, the cylinder will rotate about the magnet. The direction of rotation depends on that of the current in the cylinder, and on the situation of the poles. As to the magnet, it remains perfectly motionless; consequently, the galvanic current does not exert upon it any rotatory action. It is, therefore, possible to turn the magnet mechanically round its axis without the slightest resistance being offered by the reciprocal action of the magnet and current; the sole resistance to be surmounted in the mechanical rotation of the magnet is occasioned by the friction in the bearings of the axis. According to the mechanical theory of heat, every like phenomenon will be accompanied by a phenomenon of unipolar induction. If the battery be removed, and replaced by a galvanometer, there is indicated the rise of a current as soon as the cylinder is mechanically put in rotation. The electromotive force here consists of the mechanical work necessary to overcome the reaction of the magnet upon the current in that part of the circuit which is set rotating. This

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species of induction has received the name of "unipolar induction." The current produced is proportional to the velocity of the cylinder. The simultaneous mechanical rotation of the magnet produces no augmentation in the current generated by the rotation of the cylinder. Plücker has proved experimentally that in this case the rotation of the magnet is incapable of producing a current. For the magnet, a solenoid can be substituted, producing the same effect.* Edlund has shown† that the rotation of the solenoid about its axis cannot produce a unipolar induction current. It is therefore the rotation of the cylinder about the magnet that gives rise to the unipolar induced current; while the rotation of the magnet about its axis has nothing to do with the phenomenon. If the magnet and cylinder be connected together so as to form a compact body, the magnet is carried in the direction of the rotation of the cylinder without any modification in the induction of the magnet. The magnet acts in this case on the cylinder as if the former were immovable, and the latter alone rotating. That the magnet cannot produce unipolar induction in a conductor with which it is intimately united is, therefore, not correct. If the radius of the cylinder be sufficiently reduced for the cylinder to be in perfect contact with the magnet, this circumstance will not prevent induction taking place in the cylinder; and since induction will be produced perfectly irrespective of the thickness of the cylinder, the latter can be entirely removed, and the electrodes of the galvanometer put into immediate contact with the magnet without causing the induction to cease. The magnet itself then performs the functions of a conductor, and the induction does not result from its being put in rotation, as a magnet, but from its rotation as a conductor. This unipolar induction was first produced by W. Weber.‡

The induction at any point of the conductor depends on its motion relatively to the magnet regarded as a fixed point. As is known, this relative motion undergoes no modification, if to the magnet, as well as to the point in question, equal velocities in the same direction be imparted.

Unipolar induction ought not to be considered a real induction, but an ordinary electro-dynamic phenomenon due to the action of the magnet upon the electric currents produced by the motion of the conductor relatively to it. As for the action of the magnet, whether the currents on which it acts are produced by special electromotive forces, or by the electric fluid being carried along in the direction of motion of the conductor, is immaterial. If the unipolar phenomena are regarded as belonging to those of induction, it is necessary to distinguish the following species of magnetic induction:—

(1.) Induction due to the action of the magnet upon the induced circuit augmenting or diminishing, or in general undergoing a variation. This may take place either by the magnetic moment undergoing a change, while the induced circuit and the magnet remain at rest, and consequently do not alter their relative position; or the magnet and the induced circuit approach towards or recede from each other without the magnetic movement undergoing variation.

(2.) Induction due to the circumstances that the conductor moves in regard to the magnet without the distance from the poles of the latter to the different points of the conductor necessarily varying, and without augmentation or diminution of the magnetic moment, and this is unipolar induction.

(3.) These different species of induction may be present in combination.

In the next paper will be described some machines practically realising these unipolar phenomena.

* Pogg. Ann. vol. clx., p. 604. † Pogg. Ann. vol. clx., 617.
‡ Pogg. Ann. vol. lii., p. 353.

METROPOLITAN BOARD OF WORKS.

Electric Lighting.

The Clerk, at the last meeting of the Board, read the following report of the Works and General Purposes Committee:

Under the authority of the reference by the Board of the 25th ult. of the question of the repairing, painting, and cleaning of the offices during the recess, your committee have found it necessary to direct that a new sun gaslight be fixed in the board room, and in connection with this, their attention has been directed to the desirability of making a further trial of electric lighting. As the Board are aware, an offer was recently received from the French electrical society to provide twenty additional lights on the Embankment, and it was proposed by the Board that eight or ten of these should be placed on Waterloo Bridge, and the remainder, if arrangements could be made with the Vestry of St. Martin's-in-the-Fields, along Northumberland-avenue. From a communication which had since been received from the Vestry, it appears that they are not disposed to co-operate with the Board in the matter, on the ground of the extra expense of lighting which they consider would be thereby cast upon them, and your committee would suggest, therefore, that some of these lights should be utilised at the offices of the Board. Mr. Keates has communicated by their direction with the authorised agent of the French society, and has received from him a statement that the society will be willing to supply the lights at the rate already accepted for the lights on the Embankment and Waterloo Bridge—namely, 3d. per light per hour net. They ask, however, that the Board will furnish and lay down the wire in the subway and across the street, and will obtain the necessary consent from the parochial authority for opening the street. Your committee are of opinion, after consulting Mr. Keates, that four lights should be placed in the board room on standards erected in convenient positions, which Mr. Keates reports can be done at a comparatively trifling expense, and one light over the principal entrance of the building. It will be necessary that at the time of laying down the wires for the electric light means be adopted for establishing electrical communication with the engine shed, so that the necessary signals may be sent from the Board's office to the shed. Your committee beg to recommend in accordance with the above views, and also that the consent of the Vestry of St. Martin's-in-the-Fields be asked to the opening of the street for the purpose of laying the wires.

Mr. E. Dresser-Rogers, in moving the adoption of the report, briefly reminded the Board of its action in this matter, and said the Vestry of St. Martin's-in-the-Fields had unfortunately decided not to allow the trial of this system in Northumberland-avenue as had been suggested, although he was in hopes that they might even be induced to alter that decision. The committee thought it would prove a very useful and a very desirable improvement if four of these lamps were fixed in this board room, and, seeing that the expense when burning would not be more than the gas sun-burner now used, and the cost of bringing the wires over the road so very trifling, their recommendation was that it should be carried out.

Mr. Dalton seconded. The decision of the Vestry of St. Martin's, to which allusion had been made, was arrived at in his absence, and, as he believed, in consequence of a missapprehension of the circumstances.

Mr. John Jones did not think the experiment proposed by the committee would prove of much practical use. He had been a member of the Board for several months, and he had never once seen the gas alight. What he would suggest was that they should endeavour to arrange for the lighting of both Waterloo and Westminster bridges by means of this system.

Mr. Runtz said in his judgment this was an experiment involving an expenditure that was altogether unnecessary. It was not contemplated that the board room should be lighted permanently by means of electricity. It would be simply a temporary experiment, and his opinion was that the Board would not be justified in undertaking it.

Mr. Elt looked upon what was proposed by the committee as a wasteful expenditure of public funds.

Mr. Freeman thought it exceedingly unkind on the part of the majority of members to insist on bringing into the board room such a powerful light until they had otherwise tested its fitness for the purpose. He did not think it possible that he could sit at that Board with four lights burning with anything like comfort.

Mr. Selway observed that some time back the reading room of the British Museum was lighted by electricity on several evenings, and those who had an opportunity of witnessing it all agreed that it was a very beautiful and a very steady light. He could state from personal experience that it had no injurious effect upon the eyes whatever. The expense would be so trifling that it was scarcely worthy a consideration. In the winter time they sometimes had the gas alight all day long; electricity furnished a much more pleasant and agreeable light than was afforded by gas.

Mr. Nathan said there could be no doubt that this light was most unsuitable, if not most objectionable, to a great many people. In *The Times* printing office the electric light had been tried, but they had now gone back again to gas. He saw no reason why the work of the members of this Board should be made more unpleasant than at present, and should therefore vote against the report.

Mr. Richardson pointed out that if the light was found unpleasant they could immediately cease to use it, but in view of the fact that the additional expense would really be absolutely nothing, he thought it the duty of the Board to undertake the experiment.

Mr. Watkins: Whatever the expense will be, it will be altogether unnecessary.

On a division, the report was adopted by fourteen votes against nine.

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LONG SHORE SUBMARINE CABLES.

To lay a submarine cable between points on the same coast instead of constructing a land line seems, at first sight, both an extravagance and a departure from certainty and safety to hazard and danger. Land lines can generally be constructed for about an eighth of the sum that a submarine line can be laid for, and when once constructed can never, as many cables have, become suddenly and hopelessly irreparable. Nevertheless we find, as a matter of fact, that many cables are laid along coasts.

The reasons are, firstly, that submarine lines are easy to project, by drawing lines on a chart, with some certainty as to their practicability of construction, however uncertain may be their maintenance; secondly, the work of their construction and submergence is not only short as compared to the erection of land lines in some places, but has been brought to such perfection and certainty that the great contractors undertake to be bound both as regards cost and time, and are always willing to push on and help in various ways any sound scheme that promises an order for cable.

Land lines, on the other hand, require some careful practical surveying to ascertain even a practicable route—to say nothing of the best—as well as information regarding what stores, such as poles, can be obtained in the country, where the stores required from home must be landed, what labour and what means of transport can be obtained, and many other questions before a correct estimate can be made with any certainty; again, their construction in some places is difficult and tedious through the want of roads and means of transport, and from this cause, even after the delay of a proper survey, their construction takes up a longer period than the making and laying of a cable. These objections apply even in semi-civilised lands, but there are parts where the utterly wild and uncivilised nature of the country add a disadvantage of an indeterminate amount, which finally throws the balance so entirely in favour of a submarine line, as regards promptitude and certainty of construction, as to outweigh entirely the considerations of cost. When we turn to the question of durability and maintenance, the question is not so decidedly in favour of the submarine line. On the contrary, it is clear that where a land line can be constructed it can also be repaired, and that although it will be sure to break down and require repair, yet, with reasonable expense and careful supervision, it can be maintained at a certain yearly cost in constant order, the materials being renewed as they decay or rust. On the other hand, it does not at all follow that where a submarine line is laid there it can always be be repaired. In fact, we have numerous examples pointing the other way, rocky bottoms, great depths, and gradual but sure decay, have brought the lives of many cables to an end.

Submarine cables have a brilliant beginning; they spring into a sudden life with splendid insulation; never troubling any one in their early life with short break downs, but continuing for months, and in some cases for years, in perfect working order, without costing any expense for maintenance. Then comes a break down and interruption for weeks, then repair and an interval of work, and then another fault, and so on until at last in some cases they cannot be grappled without breaking, and their life is over. In other cases the break downs lead to finding out weak places in the route, such as rocky patches, sudden declivities, ground that acts galvanicly on the iron wires, and destroys them, &c. The cable is diverted from these, and thus that particular danger is removed, and so the whole line may, by degrees, be moved from all dangers into a safer route. It is clear that this can only be done in cases where the general route is good, with local dangers only here and there, and with a general depth that admits of easy and certain repair. In such cases a submarine line may be made to last, with moderate renewals here and there, for almost an indefinite time, and thus one of the disadvantages of a cable instead of a land line disappears. The route of a cable is therefore of the utmost consequence as regards its permanence. Of course, in crossing a deep ocean very little, if any choice, can be made, and the cable must take its chance very much of being laid over places that jump from 2,000 fathoms to a depth of say 2,100, the cable thus hanging quietly in a graceful catenary over a cliff 600 feet high.

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The outer covering of hemp and pitch slowly—perhaps very slowly—perishes, and the wire rusts; whilst various marine growths weight the cable, and thus the increasing weight and decreasing strength end in its fracture. It is evident that a cable thus breaking cannot be lifted far from the ground, and is consequently irreparable.

When running a line parallel to the coast, there is certainly some choice of route and some scope for judgment in the selection. The great desideratum is, of course, to obtain a smooth and even bottom entirely free from rock. If this can be obtained with certainty in any depth, and the choice is, consequently, only one of depth, then a depth which would put a cable lying perfectly flat on the bottom beyond the power of movement by the sea is all that can be required as regards its protection from attrition, and for this a depth of even as little as thirty fathoms would be ample. But there are questions of temperature in some localities which would be better met by a greater depth, say 100 fathoms; whilst on coasts where an ocean swell rolls in, if there is no avoiding frequent and great changes of depth, or even large portions of rough ground, it may be better to place the cable in as deep as three or four, or even five hundred fathoms to attain perfect tranquillity, although at the expense of greater difficulty in repairing when the cable has, after years, become weakened by rust. The great aim should be, however, to place the cable, if possible, on a smooth and even bed in a less depth than this, say one hundred and fifty fathoms, even if a few patches of rough ground may exist, for, should there come in time a break, the cable could be diverted round them. Some attempt should also be made to keep the cable line, if possible, within sight of bearings of the land, so as to fix its position accurately and facilitate the finding of it.

To truly and carefully select the best route along a coast requires a very full and elaborate survey, and this cannot always be obtained. So that on many lines laid with scarcely any survey it is not astonishing that the cables should be found afterwards hanging in bights and festoons over precipices, &c. Indeed, even with the best surveys in shallow water cables find out rough patches not shown on the charts. To attempt, therefore, to select a route by means of one or two flying lines of soundings, taken, perhaps, at intervals of ten miles by the ships of the cable expedition, only benefits the case to a very small extent, in spite of the facilities offered by Sir W. Thomson's sounding wire, and all that we can say is that by this precaution it is just possible that the worst route is not selected. Still, it is all that can be done; for the requirements of civilisation insist on the telegraph being laid, even at the risk of laying the cables over wrong routes in localities, which would take years to survey properly.

CORRESPONDENCE.

ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: That is rather a clever move of Dr. Lodge (p. 139) when he poses Mr. FitzGerald and myself as *versus* "all modern physicists who have made electricity a special study," and then ingeniously puts even us against each other. Not that it would be a matter of serious concern to myself if, feeling I had hold of a truth, I stood for a while alone in that sublime possession. In fact, I do occupy that position in one sense, seeing that probably all electricians without exception would have said that the laws of current and resistance are different for electricity and water; and I believe I have proved those laws identical in my article, p. 274 of last volume. But this is not the case in the general question. Mr. FitzGerald and myself are by no means alone against the world, but speak for a very large class of thinking electricians, who seek to know what is the truth which nature teaches as well as the formulæ current in the schools. But neither do the artificial school of physicists agree tolerably well among themselves, nor is there that divergence of opinion between Mr. FitzGerald and myself that Dr. Lodge supposes. I believe we agree pretty closely on all the points of difference between the natural and artificial schools, though there may be some differences in the mode in which each of us may express our thoughts. There is, however, one great difference between us which causes an appearance of divergence greater than exists; and this may as well be clearly expressed, as it will then be seen that. fundamental as it is, it does not affect the general questions in discussion. We differ simply upon the question what electricity is in its own essence, not upon the question of its laws, distribution, and actions. Mr. FitzGerald holds that electricity is an actual entity, having a quantitative existence corresponding to that of other elements. I hold that electricity has no actual existence, that it is not an element, nor a fluid; that it is not a force, but that it is like heat, simple energy—energy distributed upon chains of material molecules, with its quantitative relations governed by the atomic, equivalent and molecular constitution of the material universe. But both these views come to the same result in the other questions, and both are inconsistent with the artificial conceptions of electricity, and with any definitions which, like that of potential, for instance, involve any reference to infinity—both necessitate a perfectly definite and limited field of action.

Now, as to electromotive force, it is tolerably clear that no such force really exists in nature, but it is equally clear that it is very convenient for purposes of calculation to invent such a force, just as we do in mechanics. This is really all that is meant by our protests against the mathematical school of electricians. They are welcome to invent any formulæ *they* please to trace out results, or to express them; *we* seek to understand the natural actions which underlie the phenomena, and accept the formulæ simply as working tools of thought. E.M.F. is so admittedly such a tool that for my part I feel much less interest in it than in "Resistance." In this case the mathematical invention has actually superseded natural truth, and does mischief by giving rise to erroneous conceptions.—Yours, &c., J. T. SPRAGUE.

ELECTROMOTIVE "FORCE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my letter under this heading on p. 127, I find an *erratum*, due to inadvertence on my part:—In the 19th line, "measured it as $\sqrt{E}$" should be "measured it as E^2," this being sufficiently evident from the subsequent context. Another possible source of confusion resides in the fact that the symbol F is taken by Dr. Lodge to represent the force of attraction or repulsion between two charged conductors when the distance between them is *variable*; whereas I adopted it to signify the force which produces the movement of electricity in a circuit—a force which, I contend, may be measured by the attraction between two conductors at a *constant* distance, when these conductors are charged from the opposite poles of a source to be compared with other sources of varying electromotive "force."

To avoid future misconception, it should, I think, be stated and agreed that, taking the symbols Q and R in their usual acceptation,

$$E = Q\,R, \quad F = Q^2\,R^2 = E^2;$$

and the point in dispute is whether the term *electromotive force* properly applies to E or to F. Obviously, it cannot be applied to both; although it may be argued that there are in nature two electrical forces corresponding to those two values. This I apprehend, may be a position taken up by Dr Lodge. On the other hand, it may be argued that one of these values is purely artificial, fictitious, and non-existent in nature. This is my position, in regard to the value expressed as E.

Before the ground can be considered as cleared, something should be said—avoiding if possible any points of difference—in relation to the term *force*. This—however much it may have been abused—has in exact science a perfectly definite meaning. Force may always be represented to the mind as a *pressure* or a *pull*. It may generally be measured against the pull or attraction of gravity acting upon a variable mass. Or, supposing a force to be constant and independent of the motion it generates, it may be measured by the velocity it gives to unit mass in unit time. If it be difficult to measure it by its action, it may, according to Newton's third law, be measured by the reaction against it. It cannot be optional to measure a given force by a certain product *or* by the square of that product.

Some reference to the physical ideas of *work* and *resistance* may here be useful. If F be a resisted force, the physical idea

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of the resistance is conveyed by the relation $R = \frac{F}{W}$, W being the work done by F in a given time. If the work done by the force be *nil*, then the resistance opposed to this force is infinite. Thus work is expressed by the ratio of force to resistance, or $W = \frac{F}{R}$ when time (θ) is constant. If E be the resisted *force*, the expression $W = \frac{E^2}{R}$ is to the physicist anomalous, if not absurd. No doubt it is often dangerous to generalise upon the basis of some of the physical conceptions which occur to thoughtful and what may perhaps be termed mechanical minds; and it is well that such conceptions should be submitted to and tested by mathematical analysis. On the other hand, it is still more dangerous, if we wish to obtain an insight into natural law, to leave the *terra firma* of physics and to wander into a sea of mathematical abstractions and arbitrary creations.

Let me now try to put the subject-matter of discussion in a concrete form. We will take five voltaic cells. We are agreed that there is in each of these cells a force (the *locus* of which is at certain surfaces of contact) which causes electricity to move, and that "a very reasonable name for this something is *electromotive force*." We may agree to call unit force that which acts in each separate cell. When, however, we connect the cells in series, there is a very radical disagreement between the great majority of mathematical electricians and myself, and notably between Dr. Lodge and myself. They and he hold that the force now producing the movement of electricity is represented by the number 5; *id est* that it varies as E, which, according to the definition of this value, is certainly increased fivefold. I maintain that the force now producing the movement of electricity is expressed by the number 25; *id est* that it varies as E^2. Let us examine what may be taken as the *primâ facie* grounds for, and objections to these respective views. Perhaps this may be most concisely done by allowing two suppositious disputants to speak, limiting them strictly as to the number of words they may use.

M. Are you not aware that the quantity of electricity moved in any given circuit is fivefold when five cells in series are used instead of one cell?

P. Yes; but force and electrical quantity do not stand in the relation of cause and effect. The *work* done by the five cells is, *cæteris paribus*, twenty-five times as great as that done by one cell. So is the quantity of zinc consumed. The fundamental law of electrical action is that the quantity of electricity moved in a circuit varies, other things being equal, as the square root of the acting force, or as the square root of the work done. This law is one of the most important in the whole range of physical science.

M. I am afraid I must plead guilty to complete and entire ignorance of your law, so far at least as the relation between electrical quantity and force is concerned. How do you propose to prove that the force acting to produce the movement of electricity, is, in the case of the five cells in series, twenty-five times as great as in the case of the one cell?

P. I simply measure the pull or attraction between two plates, at a constant distance, connected successively to the opposite poles of the single cell and to those of the battery of five cells. If the attraction be a in the former case, it will be $25a$ in the latter.

M. I am well aware that the attractions will be as you say; but these *pondero-motive forces* have nothing whatever to do with electromotive force, which has no action on ordinary matter, and might, for the sake of distinction, be spelt with a ph.

P. But is not this attraction, by which *plus* electricity tends to recombine with the *minus* matter from which it has been separated, obviously the reaction against the force which has effected the separation? Is it necessary, in our theory, to assume more than that there is a force of attraction between electricity and ordinary matter, which force can be overcome by an electromotive force—the two forces, acting and reacting, being necessarily equal?

M. I do not know, nor do I care, whether there be in reality any entity corresponding to the expression "electricity." I think it most probable that "electricity" is merely a mode of energy; and this is one reason why I cannot adopt your simple but antiquated theory. I find it necessary to assume the existence of a number of electrical forces, which are best studied by means of the differential calculus and other mathematical methods, with which, unfortunately, you are not very familiar. Unless therefore you can prove to me, logically and by reference to experimental facts which are not susceptible of an interpretation adverse to your view, that there *is* such a thing as electricity, and that the force under which a fivefold quantity of this something is accumulated under given conditions is twenty-five times that under which unit quantity is so accumulated, I must adhere to my view that the value expressed by the symbol E is correctly termed electromotive force.

This, perhaps, is the stage which the discussion has reached. It cannot, probably, be carried much further until some of the foundations for a physical theory of electricity have been laid open for the inspection and criticism of your mathematical readers. I purpose offering you some rough contributions towards such a theory; though I fear that I cannot devote to the task before me time and energy commensurate with its importance.

In conclusion, permit me to say a few words in reference to the law of Coulomb expressed by the equation $A = \frac{Q\,Q'}{d^2}$. If the surfaces on which Q and $Q_,$ are accumulated be "bounding surfaces" in a simple inductive circuit, then $Q = Q_,$, and the equation may be written $A = \frac{Q^2}{d^2}$. These equations express two laws, one of which is unquestionably true as a fundamental law, and the other altogether false, excepting as a law of phenomena occurring under particular and special conditions. The former law may be expressed as $A = Q^2$, the latter "law" as $A = \frac{1}{d^2}$. Both are of strange interest from an historical point of view. The former would not square with preconceived ideas; it was termed "a negation of the equivalence between cause and effect," it was strenuously denied, explained away by ingenious and complicated hypotheses of reflex action, and ultimately accepted, almost tacitly and with a bad grace, under the stern compulsion of verifiable fact. The latter was necessary to certain *a priori* conclusions involving the consideration of electricity as a radiating force, and a very cherished analogy between electricity and gravitation. Experimentalists set to work to verify it, and failed again and again. It was explained to them that the "law" *must* be true, and that it could be verified by experimenting in a particular way, making certain allowances for errors of observation, and bringing a little *bonne volonté* to bear upon the question. In fact, working in an atmosphere of bias, the experiments (which never gave the desired result with flat surfaces charged with a constant quantity) were so carried out, by means of small spheres, that the redistribution of electricity which occurred when the distance between them was varied allowed of results being obtained in accordance with the "law of the inverse squares of the distances." Up to the present day, this "law" has been a stumbling block and a snare to all who have attempted to work out an electrical theory. The "law of the squares of the quantities," on the other hand, is true under *all* conditions, and admits of no exception. Since at a constant distance between two surfaces charged from the poles of a source the attraction (A) must vary as the true electromotive *force* (F), we have, as the expression of this law:

$$F = Q^2.$$

When the distance is varied, the inductive resistance is also varied; and it is easy to show that, in order to maintain Q constant, E must be varied as R; that is to say:—

$$F = R^2,$$

F being here, not the attraction between the surfaces (which is dependent upon the redistribution of electricity, which takes place when the distance between them is varied), but the *force* necessary to maintain Q constant when R is varied.

Combining these two laws, we have:—

$$F = Q^2 R^2.$$

Whence

$$Q = \frac{\sqrt{F}}{R},$$

the equation given in my last letter.—Yours, &c.,

DESMOND G. FITZGERALD.

ON AYRTON AND PERRY'S NEW THEORY OF THE EARTH'S MAGNETISM, WITH A NOTE ON A NEW THEORY OF THE AURORA.

BY H. A. ROWLAND,

Professor of Physics in the John Hopkins University.*

Some years ago, while in Berlin, I proved by direct experiment that electric convection produced magnetic action; and I then suggested to Professor Helmholtz that a theory of the earth's magnetism might be based upon the experiment. But upon calculating the potential of the earth required to produce the effect,

* From the *Philosophical Magazine* for August, 1879. Communicated by the Physical Society, having been read June 29th.

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I found that it was entirely too great to exist without producing violent perturbations in the planetary movements, and other violent actions.

I have lately read Professors Ayrton and Perry's publication of the same theory; and as they seem to have arrived at a result for the potential much less than I did, I have thought it worth while to publish my reasons for the rejection of the theory.

The first objection to the theory that struck me was, that not only the relative motion, but also the absolute motion through space of the earth around the sun might also produce action. And to this end I instituted an experiment as soon as I came home from Berlin.

I made a condenser of two parallel plates, with a magnetic needle enclosed in a minute metal box between them; for I reasoned that, when the plates were charged and were moved forward by the motion of the earth around the sun, they would then act in opposite directions on the enclosed needle, and so cause a deflection when the electrification of the condenser was reversed. On trying the experiment in the most careful manner, there was not the slightest trace of action after all sources of error had been eliminated.

But the experiment did not satisfy me, as I saw there was some electricity on the metal case surrounding the needle. And so I attacked the problem analytically, and arrived at the curious result that if an electrified system moves forward without rotation through space, the magnetic force at any point is dependent on the electrical force at that same point—or, in other words, that all the equipotential surfaces have the same magnetic action. Hence, when we shield a needle from electrostatic action, we also shield it from magnetic action.

This theorem only applies to irrotational motion, and assumes that the elementary law for the magnetic action of electric convection is the same as the *most simple* elementary law for closed circuits. Hence we see that, provided the earth were uniformly electrified on the exterior of the atmosphere, there would be no magnetic action on the earth's surface due to mere motion of translation through space.

In calculating the magnetic action due to the rotation, I have taken the most favourable case, and so have assumed the earth to be a sphere of magnetic material of great permeability, μ. It does not seem probable that it would make much difference whether the inside sphere rotated or was stationary, or at least the magnetic action would be greatest in the latter case; and hence, by considering it stationary, we should get the superior limit to the amount of magnetism.

Let a be the radius of the sphere moving with angular velocity w, and let σ be its surface density in electrostatic measure, and n the ratio of the electro-magnetic to the electrostatic unit of electricity. Then the current-function will be

$$\phi = \frac{\sigma}{n} w a^2 \int \sin\theta \, d\theta = -\frac{\sigma}{n} w a^2 \cos\theta.$$

Hence (Maxwell's "Treatise," § 672) the magnetic potential inside the sphere is

$$\Omega = -\frac{8\pi}{3}\frac{\sigma}{n} w a r \cos\theta,$$

and outside the sphere

$$\Omega' = \frac{4}{3}\pi\frac{\sigma}{n} w a^4 \frac{\cos\theta}{r^2}.$$

The magnetic force in the interior of the sphere is thus

$$F = \frac{8}{3}\pi\frac{\sigma}{n} w a,$$

or the field is uniform. If the electric potential of the sphere on the electrostatic system is V, we may write $F = \frac{2}{3}\frac{w}{n} V$, which is independent of the dimensions of the sphere.

In this uniform field in the interior of the sphere, let a smaller sphere of radius a' be situated; the potential of its induced magnetisation will be

$$\Omega_1 = \frac{\mu - 1}{\mu + 2} a'^3 F \frac{\cos\theta}{r^2}.$$

Hence the expression for the potential for the space between the two spheres will be

$$U = \frac{2}{3}\frac{w}{n} V \left\{ -r\cos\theta + \frac{\mu - 1}{\mu + 2} a'^3 \frac{\cos\theta}{r^2} \right\};$$

and outside the electrified sphere it will be

$$U' = \frac{w}{n} V \left(a^3 + 2 a'^3 \frac{\mu - 1}{\mu + 2} \right) \frac{\cos\theta}{r^2}.$$

Let us now take the most favourable case for the production of magnetism that we can conceive, making $a' = a$ and $\mu = \infty$; we then have $U' = \frac{w}{n} V a^3 \frac{\cos\theta}{r^2}$, which is the potential of an elementary magnet of magnetic moment $\frac{w}{n} V a^3$. But Gauss* has estimated the magnetic moment of the earth to be $3{\cdot}3092\, a^3$ on the millimetre mg. second system. Hence we have $V = 3{\cdot}3092 \frac{n}{w}$ for the potential in electrostatic units on the mm. mg. second system. In electro-magnetic units it is thus $V_1 = 3{\cdot}3092 \frac{n^2}{w}$; and hence in volts it is this quantity divided by 10^{11}.

As the earth makes one revolution in 23 h. 56 min. 4 sec., or in 86,164 seconds, we have $w = \frac{2\pi}{86{,}164}$; and

$n = 299{,}000{,}000{,}000$† millims. per second.

Hence the earth must be electrified to a potential of about 41×10^{15} volts‡ in order, under the most favourable circumstances, to account for the earth's magnetism. This would be sufficient to produce a spark in atmospheric air of ordinary density of about 6,000,000 miles! Professors Ayrton and Perry have only found the potential 10^8 volts, or 400,000,000 times less than I find it.

It was this large quantity which caused me to reject the theory; for I saw what an immense effect it would have in planetary perturbations; and I even imagined to myself the atmosphere flying away, and the lighter bodies on the earth carried away into space by the repulsion. And, doubtless, had not Professors Ayrton and Perry made some mistake in their calculation by which the force was diminished 16×10^{16} times, they would have feared like results.

For according to Thomson's formula, the force would be equal to a pressure outwards of $r = \frac{V^2}{8\pi a^2}$, which amounts to no less than 1,800,000 grms. per square centimetre! or 10,000 kil. per square inch! Such an electrostatic force as this would undoubtedly tear the earth to pieces, and distribute its fragments to the uttermost parts of the universe. If the moon were electrified to a like potential, the force of repulsion would be greater than the gravitation attraction to the earth, and it would fly off through space.

For these reasons I rejected the theory, and now believe that the magnetism of the earth still remains, as before, one of the great mysteries of the universe, toward the solution of which we have not yet made the most distant approach.

In connection with the theory of the earth's magnetism, I had also framed a theory of the aurora which may still hold. It is that the earth is electrified, and naturally that the electricity resides for the most part on the exterior of the atmosphere—and that the air-currents thus carry the electricity towards the poles, where the air descending leaves it—and that the condensation so produced is finally relieved by discharge.

The total effect would thus be to cause a difference of potential between the earth and the upper regions of the air both at the poles and the equator. At the poles the discharge of the aurora takes place in the dry atmosphere. At the equator the electrostatic attraction of the earth for the upper atmospheric layers causes the atmosphere to be in unstable equilibrium. At some spot of least resistance the upper atmosphere rushes towards the earth, moisture is condensed, and a conductor thus formed on which electricity can collect; and so the whole forms a conducting system by which the electric potential of the upper air and the earth become more nearly equal. This is the phenomenon known as the thunderstorm.

Hence, were the earth electrified, the electricity would be carried to the higher latitudes by convection, would there discharge to the earth as an aurora, and passing back to the equator would get to the upper regions as a lightning discharge, once more to go on its unending cycle. I leave the details of this theory to the future.

Baltimore, May 30, 1879.

APPENDIX.—Since writing the above, Professors Ayrton and

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* Taylor's "Scient. Mem.," Vol. ii., p. 225.

† From a preliminary calculation of a new determination made with the greatest care, and having a probable error of 1 in 1,300.

‡ That this is not too great may be estimated from my Berlin experiment, where a disc moving 5,000,000 times as fast as the earth with a potential of 10,000 volts, produced a magnetic force of $\frac{1}{50000}$ of the earth's magnetism, $5{,}000{,}000 \times 10{,}000 \times 50{,}000 = 2{,}500{,}000{,}000{,}000{,}000$, which is of the same order of magnitude as the quantity calculated, namely 61×10^{15}. It can be seen that this reasoning is correct, because the formulæ show that two spheres of unequal size, rotating with equal angular velocity and charged to the same potential, produce the same magnetic force at similar points in the two systems.

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Perry's Paper has appeared in full; and I am thus able to point out their error more exactly. Their formula at the foot of page 406 is almost the same as mine; but on page 407, in the fourth equation, the exponent of n should be $+\frac{1}{3}$ instead of $-\frac{1}{3}$, which increases their result by about 600,000,000, and makes it practically the same as my own.

Rotterdam, July 13th.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).

The ordinary half-yearly general meeting of the proprietors of this Company was held on Friday, August 8, at the City Terminus Hotel, Cannon-street, Viscount Monck, the Chairman, presiding.

Mr. John Grant (the Secretary) having read the notice convening the meeting, and the minutes of the last general meeting, held on the 7th of February,

The report, an abstract of which has appeared in *The Electrician*, was taken as read.

The Chairman, in moving the adoption of the report and accounts to the 30th June, said he was glad to state that, notwithstanding the depression which they were all aware still, unfortunately, continued in most branches of commercial enterprise, their traffic within the last half year had been very prosperous. There had been an increase in the half year at the rate of about £50,000 a year, and they would have found the very pleasant indication of that fact in the addition which the Board had been able to give to the interim dividend—of ½ per cent. more than they had been in the habit of giving. That, he thought, was a tangible proof — though he did not know that they required to have it given them—of what he had often stated from the chair — that the Directors were desirous of distributing among the proprietors every shilling of money they earned, which they believed was not absolutely necessary for maintaining the credit and permanence of the enterprise. So far with regard to the earnings of the past half year; and he might state that those of their cables which were in working order were working satisfactorily, and were carrying the traffic in as efficient a manner as ever. The cable of 1869, which broke down some time in the spring, was being repaired as rapidly as possible. They had every reason to believe and hope that they would finish the repairs satisfactorily; but the truth was that the exceptional character of the season, which was the continual subject of conversation here, had prevailed also on the other side of the Atlantic, and the fogs were such that it had been almost impossible for the ship to go to sea for a sufficient time to repair the cable; but there had been no failure in the attempt to repair it. So far as they had gone they had been fully successful, and he had very little doubt, if the weather changed, and became what would be satisfactory to them, that they would succeed in the attempt. With regard to the accounts, if they referred to the abstracts that had been furnished for the last two half years, in compliance with the promise made about a year ago to the shareholders, they would find that the expenditure of this half year appeared to be about £4,575 larger than that of last half year; but, on the other hand, there were items in the accounts of this half year which were less than the corresponding items of last year, and reduced the apparent balance against them by £2,398, leaving a balance of £2,177 to be accounted for as the increase in the present half year. There had, however, been certain extraordinary charges in the half year which entirely accounted for the increase, and when he mentioned them he thought they would say that they were not to be questioned. In the first place there was an increase in the article of stationery of £200; this might seem a very large increase, but it was entirely owing to the fact that they were obliged to call an extraordinary meeting, and the expenses of sending out circulars and printing amounted to that sum. Then there was £500 for the entertainment of the International Telegraph Conference which had been sitting in London. All the other telegraph companies contributed their share towards the entertainment of those gentlemen, who came to this country from all parts of the world to arrange the international administration of telegraphy. When the conference was held in other capitals our delegates were treated with the greatest possible kindness and hospitality, and he was certain that the shareholders would not have considered it right that their Company should not co-operate with the other companies and with the Post Office department of the Government in receiving those foreign gentlemen when they came to England in a manner worthy of the country. That, then, accounted for £700 of the increase. Under the head of "maintenance of land lines, instruments, and instrument stores," they would see an increase of £1,600 and that was owing to the fact that electrical instruments, like all other human things, wore out, and they had been obliged to send out to foreign stations entirely new sets of instruments, which accounted for the expenditure. That accounted for £2,300 of the net increase in the half year, but in addition to that—and which showed at once that, so far from being a real increase in the expenses of the half year, there was, in fact, a diminution—there was another item, an extraordinary item, of £1,000 for new buildings at Valentia. Therefore, instead of there being an increase in the half year, when they came to deduct the economies effected, and these large extraordinary expenses, which were absolutely necessary and inevitable, they found that the expenditure was less, and had been more economical than for the previous one. The reserve fund, or renewal fund, as they were aware, was being increased at the rate of £150,000 a year, and at the end of this year would amount to half a million of money. With regard to the powers they took at the extraordinary meeting in April last—reported in *The Electrician*—the shareholders were aware of the reasons of the Board for demanding from them those extraordinary powers—the power, namely, to establish a company in connection with this Company in France. At the time they gave the Board those powers he announced to them the object which they had in view in asking for them. He told them that they adopted it as a precautionary and a fighting measure with respect to the new company, which was proposed to be established in France, and he asked them to give the Board their confidence to use that measure as they thought best for the interests of the Company. Well, they had taken no further step in the matter; up to the present time they had not thought it would be desirable in the interests of the Company to take any further steps. They, however, retained those powers, and would use them if they deemed it necessary or desirable for the interests of the shareholders, whom he had to ask to treat the Board with the same confidence as they had always done, and allow that question to remain for the consideration of the Board. They had applied the duplex system to their cables, and they had found immense benefit from it. He was not quite sure whether the word "duplex" was realised—that they could carry double the amount of traffic, but it allowed them to carry an enormously increased traffic on the same cables they had hitherto been working. He now came to what was really the most important point touched on in the report, and that was the policy of laying another cable next year. With respect to that question, they must remember two things. In the first place they must endeavour to maintain the position of this Company as the most powerful and the most efficient company for the purpose of telegraphy in this country. In order to do that, he thought they ought never to allow themselves to get below the position of having three cables at their command. If the traffic continued increasing, if there should be any development of commercial enterprise, he did not know that even with the present rate of tariff they would be able to carry the traffic on two cables; but in addition to that they must remember that their arrangements with other companies depended on their having two cables always in efficient operation, and he thought they would agree with him that it would not be prudent or advisable that they should barely maintain what entitled them to hold their position in all their working arrangements with other companies, but that they ought always to have a reserve of power in case of any accident or casualty occurring to the cables they possessed. Fortunately for the policy which the Board had pursued steadily, they were in a position to realise these views without asking for a single shilling of money from the shareholders or any one else. He had already told them that the reserve fund at the end of this year would amount to half a million of ready money, including the cable in store. In addition to that they had the shore ends of the cables of 1865 and 1866, which were in perfectly good order, and which they were all aware were a very large proportion of the expense of laying down a cable across the Atlantic—the shore ends were in proportion the most expensive part of a cable. They could use these shore ends at both sides, and all that they would have to provide was the deep-sea cable, and he believed they could do that for less than the amount at their credit. He did not know whether he had said enough to commend this policy to their judgment. He confessed that he himself thought it was absolutely necessary and desirable that they should adopt it, and that they should keep themselves in the position of a company bound to maintain two cables, but still with the power in reserve of a third cable in case of any accident or casualty. So much for the policy which they meant to adopt in future with regard to their cables. At their last general meeting it was proposed to establish a superannuation fund for their officers by an arrangement with an assurance company. The arrangement was that their Company was to pay half of the premium necessary to obtain the superannuation, and that the officers out of their salaries were to contribute the other half. He explained the whole system at the last meeting, but a question was raised in the room as to the propriety of taking that step at the moment. He did not think there was any opposition on principle to the project, but the question was raised as to whether that was the proper time for doing the thing, and the Board agreed to postpone the adoption of the system until the next half-yearly meeting, and to issue proxies to the proprietors generally upon that very point, and ask them to give their votes on it. They had adopted that policy, and he held in his hand the return made to them in answer to that appeal. In round figures the votes in favour of the project were £1,251,333, and against it £22,328, and therefore having taken the course which was suggested at the meeting and accepted by the Board they found that the proprietors of the Anglo-American Telegraph Company, by an overwhelming majority, had decided that the proposition of the Board should be adopted. He then moved the resolution for the adoption of the report and accounts.

Captain Augustus Terrick Hamilton, the deputy chairman, having formally second the resolution,

Mr. Jackson asked for an explanation of the large item of £497 for the half year (nearly £1,000 a year) for medical attendance at the stations on the other side. It seemed a very large amount in face of the competition they were threatened with, and which would have the effect to a certain extent of reducing their very moderate dividend. He thought the sum was over liberal, considering the salaries of the staff; and as against this £497 he found that the same item in the accounts of the Direct United States Cable Company stood at £7. He did not dispute the propriety of the charge, but thought it was carrying on the business on a somewhat imperial system to allow £1,000 a year for medical attendance for a staff of 150. He did not vote against the insurance fund, but he thought it would have been infinitely more satisfactory to the proprietors if they could have seen in the report what the permanent charge to the Company in connection with this fund would be. The fact that they had lost two cables ought to make economy an imperative question with them, and it should be rigidly adhered to in any future arrangement the Board might make. He thought it was to the interest of the Telegraph Construction Company to make as many cables as they could, and that those which were laid should perish as soon as possible. He had asked on a former occasion whether the Board were themselves taking serious steps to find out how they could protect the Company's cables, for as they were now laid the question of protection was certainly defective. They now proposed, too, to lay down another million of money, possibly with the same result, or in some degree with similar results which attended those of the 1865 and 1866 cables. He certainly thought that steps should be taken for the protection of the cables, but, of course, if nothing was attempted nothing would be done.

Mr. Seeley thought, as to the question of laying another cable next year, that there was a likelihood, in the course of time, that the new French company, which were about to go into opposition with this Company, would have to come into arrangements with this Company, either by amalgamation or by an arrangement similar to that with the Direct Company, and in that case this Company would have the same advantages with the French Company's cable that they had now with that of the Direct Company. They had two cables now, and the one with the Direct Company, and if they got an

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arrangement with the French company there would be a fourth; and with the duplex system applied, that would be equal to working with eight cables.

Mr. HENRY WEAVER (the general manager): No, no, no, no.

Mr. SEELEY said the Chairman stated that if the duplex system did not double the carrying capacity of a cable it did very nearly do so. He would assume that the duplex system increased by one-third the carrying capacity of a cable. [Mr. Weaver again dissented.] That with actually four cables made them equal to six, and would not that be sufficient for the traffic they were now carrying, and allow for an increase in the traffic when trade revived? Considering the very great loss they might be put to in fighting with the French company, he thought it would be more judicious to retain the money in hand than lay it out on another cable. They had really three cables at work—two of their own, and one of the Direct Company, and that, he should think, was sufficient for the time being—at any rate, till the "war" was over.

Mr. NEWTON thought that with two cables in work and one repairing they had really three cables. With regard to the insurance fund, he believed it applied to a staff of over 300 or 400, some of whom received very high salaries. He thought they should have something like a guarantee that the use of it should be limited to those in their service not receiving such very high salaries. Men in ordinary life had to look after their families themselves; and he thought, as he urged at the last meeting, that it was only the great joint-stock companies of London, which had large businesses, large reserve funds, and which would be certain to exist for, say, 50 or 100 years, that had established such a fund. They could not, however, say that this was the case with this Company with their stock at 50 per cent., and he maintained that they should certainly be in a stronger position before they established the fund. He should not, however, oppose it himself, not having sufficient interest in it, but he thought they should have a guarantee that its advantages would apply only to the underpaid and not the highly-paid members of their staff. Was the item of £1,005 in Abstract B a portion of the assurance fund charged in the expenses?

The CHAIRMAN replied in the affirmative.

Mr. NEWTON, continuing, said he thought the shareholders were not getting large enough dividends to go into acts of charity. As to the large number of proxies sent in in favour of the project, it was to be expected that Englishmen would deal with a question of charity in that manner; and he was only astonished that double the number of proxies in favour of the scheme had not been sent in. But it was to be remembered that all the money thus to be paid by the Company to the fund would not come out of the pockets of those who voted in favour of the project—they compelled people who were not of their opinion to join them in this charitable act.

Mr. WALKER said that the report showed a revenue increasing very much more in proportion to the expenses. It showed (he said) that they could pick up their cables, and that the traffic was increasing. He thought these were features which must commend themselves to the shareholders' approbation; and he also thought worthy of commendation the policy of the Directors in putting by a good reserve fund. For this, however, they were a good deal indebted to the patience of the deferred shareholders, who were a very patient body; but still he thought the existence of such a fund was beneficial to the shareholders all round. He could not, however, go with the Directors in the matter of the threatened competition with the proposed new French company, and as to the best mode of meeting it, as indicated in the ninth paragraph of the report. The Directors thought that the best way of meeting the affair of putting what they before called a useless cable under the sea was to put another useless cable under the sea. He, however, thought that they had better keep their money and buy the cable of the French company when it was to be sold. He assumed, as the foundation of his remarks, that the Company's present cables were sufficient to carry far more than the present amount of traffic. They had two cables in order, and would probably repair another, and the Direct Company had another cable; and he, therefore, asked the Directors to pause before putting half a million of money into the sea, in the shape of another cable, to rot out as the other cables were. He hoped the Directors would reconsider this question. It was not only the first expense of laying an additional cable that had to be considered, but the extra expense of repairing them. If they had four cables the expense of keeping them was about double what it would be if they had only two. Let them wait till the end of the competition, when they might buy up the French company's cable.

The CHAIRMAN, in reply, said he would try to the best of his ability to answer the observations addressed to him, and he would begin with Mr. Jackson's criticism upon the medical expenditure of the Company. In the first instance Mr. Jackson very much understated the number of persons for whom this medical attendance was provided. The number of their staff at the different stations where this expenditure occurred approached very closely to 400—he meant including their wives and families [laughter]. Perhaps they might say, "What business have we to provide medical attendance for their wives and families?" Well, the answer was that they could not provide it for themselves. One could not get medical attendance where there was no doctor, and their stations at Valentia, Heart's Content, Duxburg, and St. Pierre were all of that character. Therefore they had not only to provide medical attendance, but the attendant who supplied it to people who would otherwise be left altogether without anything of the sort. The consequence was that they were obliged to pay a man—he would not say "by the piece," but they were obliged to pay a man for going and living there to give the attendance. He did not think the shareholders would dream for one moment of the Company sending their *employés* to do their work, and perish of disease on a barren rock, where they had no means of getting medical attendance or comforts. That was the sole answer he had to make, and he was certain that the meeting would support it. Mr. Jackson had also said a good deal with respect to the character of the cables and experiments for their protection. Well, they had been carrying out experiments to no end, both directly and indirectly. They were in communication with the other cable companies, who were equally interested with themselves in the discovery of a good type of cable, but they must remember one thing. Mr. Jackson said that these things should be carried on by the Company perfectly independently of the Telegraph Construction Company. He should be very much inclined to agree with Mr. Jackson if the thing were possible. To carry out such experiments they must either be cable manufacturers themselves, or they must have an arrangement with those who were.

Mr. JACKSON: Give a premium.

The CHAIRMAN said he should not like to come before them at a time when they would be suffering from the competition of their French rivals and ask them, instead of getting some moderation of the dividend, to pay £30,000 as a premium for something which might turn out a complete failure. The Board had the responsibility of getting for the shareholders the best cable that could be constructed, and they took every measure they thought most desirable for obtaining the result without unduly trespassing on the funds of the Company. With regard to the endowment fund, the most that the Company could ever be called on for in a year was £2,450—that was the *maximum* amount of expenditure under that head. As to Mr. Newton's remark about the class of officers to whom this arrangement should be applied, that gentleman had made use of two or three words which he (the Chairman) thought on consideration he would feel inclined to withdraw. In the first instance, he spoke of one class of the Company's servants being overpaid and another underpaid, but he should be sorry for it to be supposed that in relation to each man's work any of their servants were underpaid. They tried to arrange every man's salary to the work he had to do, and they did not wish it to be done in a niggardly spirit, nor did he suppose that the shareholders did. Another word Mr. Newton used was that the establishment of the fund was an act of charity, but it was no act of charity at all. It was based on a principle which all employers of labour, from the State downwards, had found themselves forced to apply to their staff. It was not, therefore, he repeated, an act of charity, but was in point of fact a mode of giving some addition to the salaries of their staff which should benefit them more than a direct payment of money, and in a manner which should be less onerous to the Company. It would also promote the practice of prudence and foresight among their staff. It might be supposed *a priori* that the servants of the Company could ensure their lives on this principle to any extent, but by an arrangement they had made no servant of theirs could avail himself of the plan beyond the sum of £1,000. With regard to Mr. Seeley's observations, no doubt the duplex system had increased the power of their cables for the transmission of messages, but their power for transmitting the traffic was really a question which could only be answered effectively and thoroughly by his friend the general manager. They no doubt had sufficient power with two cables to transmit their present traffic; but if they were to go into competition they must remember that there was only one way—that was, by reducing the tariff; and if they went into competition with the French company and the traffic largely increased, they would not be able to carry it with their present amount of cable power. But that was only one branch of the subject. The hon. gentleman who spoke of their having two cables in working order entirely forgot that that was the *minimum* they were bound to maintain in order to support their relations with the Direct and other companies. If one of those cables were to break the next morning—and an accident of that kind might happen to the best cable in the world—they would not be in a position on their part to carry out their agreement with the Direct Company; and did they think it well—he would not say to sacrifice their position—but to allow it to become dependent on the continued efficiency of one single cable? He strongly adhered to the opinion he had expressed—that they should always be in possession of sufficient reserve power of cable—they must not only have cables sufficient to transmit the messages committed to them, but to fulfil their engagements in other quarters. It had been urged that they should postpone the laying of the cable till the "war" was over, but there were wars and wars, some were long and some were short, and they might possibly have completed their warfare before they laid the cable.

Mr. WALKER asked if the Board had any information as to the probability when the new French cable would be laid, and how the work was going on.

The CHAIRMAN said he believed they were going on as fast as they could. He had no official information on the subject. He was not in amicable relations with them, and they did not confide their secrets to him [laughter].

A SHAREHOLDER asked what the new cable which the Board proposed to lay was likely to cost.

The CHAIRMAN said they had no estimate. In fact they had done nothing except adopt the policy. He then put the resolution for the adoption of the report, and the motion was carried unanimously. Continuing, he submitted a resolution approving the establishment of the endowment assurance fund, and authorising the Board to carry the arrangement into effect, as expressed or with any modification which the Board from time to time might require or approve.

Sir DANIEL GOOCH, Bart., M.P., a Director having seconded the motion,

The CHAIRMAN put it in the usual manner, and declared it carried by 24 to 13. The majority of the meeting, therefore, did not take part in the voting.

On the motion of Mr. SEELEY, a vote of thanks to the Chairman, Directors, and staff was passed, and

The CHAIRMAN having replied, the proceedings terminated.

SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of the proprietors in this Company was held on Wednesday, the 13th inst., at the Cannon-street Hotel, under the presidency of Sir James Carmichael, Bart. The report stated that the result of the six months' working enabled the Directors to add the usual proportion of the receipts to the reserve fund, and to recommend a dividend at the rate of 17¼ per cent. per annum. The dividend for the corresponding period of the year 1878 was at the rate of 17 per cent. per annum. The Directors had established, in concert with the German Union Telegraph Company, a duplex system of telegraphy on a wire between London and Emden, for the transmission of messages passing over the special wire erected by that company between Emden and Vienna. The proportion of the cost of the new system was £302, as charged in the accounts.

The CHAIRMAN, in moving the adoption of the report, said he thought he might congratulate them on the balance-sheet, because, notwithstanding the bad times, there had been a slight increase in their traffic, and at the same time there had been no corresponding increase of expenditure; in fact, the expenditure remained the same as last half year. With

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regard to the alteration of the tariff, which would probably occur next year, the Directors had been from the commencement of the Company advocates of reasonable rates; and many years ago he himself tried to obtain a reduction of their present rate from the French Government, and also an assimilation of the provincial rates which were so complained of. At that time his suggestions were not received by the French Government. At the last Telegraph Conference, however, there had been a general expression of opinion in favour of the adoption of the word rate. Personally, from his experience (which was pretty long) of telegraph matters he should have preferred to commence with a ten-word rate, which was also advocated by the French delegates, but the opinion of most of the delegates of other countries was in favour of an absolute word rate. Such being the case, it became their duty to try and carry that alteration out in the best and most efficient manner they could in the interests of the public and of the shareholders. He did not wish to prophesy but he thought they might look to what was going on on the Continent, and judge for themselves what would be the result. The word rate had been tried for some time between France and Germany, and also internally in France, and from information which he had derived there had no doubt been a considerable increase since its adoption both in the number of messages carried and the receipts, but against that they must set the increase in the expenditure. If they increased their business, as they would, no doubt, with the word rate, they would have increased expenses—a large number of additional messages would necessitate additional clerks and instruments, and possibly they would have to use the duplex on many of their lines. One thing, he was happy to say, was that no additional wires would be required. They had plenty to carry any additional amount of traffic, and, therefore, he did not think any additional cable would be required for some time; but if so they were in the happy position of having an ample reserve to fall back upon [hear, hear]. The new building they were authorised at the last meeting to construct was going on now tolerably rapidly. With regard to their cables they were in good working order; and in fact they were going on as well as they could expect. He then moved the adoption of the report.

Mr. Capper formally seconded the motion.

The Chairman, in reply to questions, said that they had no reason to believe that the estimate for the new building would be exceeded. The reserve fund was entirely a shareholder's question, and they decided some time ago to transfer to that fund the amount which was now put to it, and which he could not but believe was satisfactorily sufficient. They had now £70,000 invested in the funds and in railway debenture bonds, and the interest which accumulated every year was also added to the reserve fund. He then put the motion, which was carried unanimously. Continuing, he moved the payment of the dividend recommended in the report.

Mr. King formally seconded the motion, which was carried unanimously.

Baron Stern then moved the re-election of the retiring Directors.

Mr. Givens seconded the motion, which was carried unanimously.

Mr. Arthur Otway, M.P., in returning thanks for his re-election, said he thought that the Company was in a very prosperous condition, notwithstanding the depression of the times, and he thought that that was not altogether to be separated from the administration of the Company. He regarded the general working of the Company as most satisfactory. The very excellent dividend they were able to declare showed no signs of diminishing. As to the word rate, it was to be hoped that the development of the traffic would make up for the loss that would accrue in the first place. He believed that it would eventually be a great success, and also that the time would come when telegraphy would be the common form of communication.

On the motion of the Chairman, seconded by Mr. Smith, the retiring auditors were re-elected.

A vote of thanks to the Chairman and the other Directors terminated the proceedings.

RECENT PATENTS.

4462. Producing Electric Light, &c., *J. T. Sprague.—Dated 16th November*, 1878. 6*d.*

This consists, first, in substituting for the ordinary electric arc, consisting of conductors with a variable space between them, a closed circuit consisting of a conducting substance capable of carrying the current united with a substance capable of becoming incandescent and luminous. Secondly, the construction of lamps for electric and other lights fitted with a translucent reflector below the light and opaque reflector above.

4635. Electric Lighting, *E. J. C. Welch.—Dated 15th November*, 1878. —*(Not proceeded with.)* 2*d.*

This relates to improvements on patent No. 4278, dated 25th October, 1878, and consists in the employment of a double set of moving contact pieces, one set insulated from the other, and one connected to the positive pole of the generator, and the other to the negative pole, the wires of each circuit being connected with two fixed contact pieces. The parts are so arranged that the current shall be reversed in each circuit one or more times during each revolution of the two moving sets of contact pieces.

4645. Obtaining Electric Light, *J. S. Sellon, W. Ladd, and H. Edmonds. Dated 15th November*, 1878. 6*d.*

One of the electrodes consists of iridium in a practically pure state. The iridium in any suitable shape to form a "point" is fixed in a metallic setting, preferably platinum, and this setting is affixed to a plug of copper. Instead of employing rods or wires of platinum in a closed circuit for emitting light, alloys of this metal with iridium are used.

4646. Electric Lamps, *J. S. Sellon, W. Ladd, and H. Edmonds. Dated 15th November*, 1878. 6*d.*

Carbon points are inserted in guides in which they move freely, and bring their extremities into contact with fixed rests carried by supports connected to their respective guides, and forming portions of the circuit. If the points are set at an angle the guide for one is pivotted to a fixed support, and is capable of rocking to put its carbon in or out of contact with the carbon of the fixed guide. When the lamp is not in use the points are in contact, and to separate them and produce the electric arc an electro-magnet is placed within the circuit, and so as to act on the pivotted guide, and rock it on its fulcrum as soon as the current is established.

4669. Preventing Accidents to Railway Trains, *W. R. Lake.—Dated 16th November*, 1878.—*(A communication.) (Not proceeded with.)* 4*d.*

A rail is laid between the ordinary rails, and a trailing piece in connection with an electrical machine carried by the train enables the situation of the train to be known at the station last left, and the one which the train will next pass. The rail is in an electric circuit, and the trailing piece rests in contact therewith.

4671. Production, Regulation, and Distribution of Electric and Electro-Calcic Lights, *W. L. Scott.—Dated 18th November*, 1878. 6*d.*

This consists, first, in the adaptation to, and employment in connection with apparatus and appliances for electric lighting, of a condenser or condensers, the surface of such condensers being equivalent to about one and a quarter times the surface of the conducting wires, plus such additional length of the same wire as may be of equal resistance to the resistance of the burner. Secondly, in the manufacture of the electrodes, which are made of blocks, cakes, plates, spheres, domes, discs, or other suitable forms of lime, magnesia, alumina, or other suitable oxide of the earthy or alkaline earthy metals, or mixture thereof, and one or more is affixed or placed between or against any wires, points, pencils, or surfaces, from which electric lights, sparks, or incandescence is or are to radiate or be emitted. Thirdly, in the use of platinum or other suitable metal in the form of wires, helices, &c., in connection with and in juxtaposition to the electro-calcic burners.

4672. Working Railway Signals and Points, *G. Lund and A. Burrows.—Dated 18th November*, 1878.—*(Not proceeded with.)* 2*d.*

A repeater or small semaphore arm is worked electrically by the signal or point, at a certain part of the movement of which a resistance coil is brought into action, so that there is first a stronger and then a weaker power sent through the conducting wire. By this means the signalman will be able to see if the signal or point has moved to the full extent, as the first current has the effect of moving the repeater half-way, and the second current withdraws a stop and allows it to complete the distance it travels.

4693. Apparatus for Dividing Electric Light, *A. Reimenschneider and F. S. Christensen.—Dated 19th November*, 1878. *(Not proceeded with.)* 4*d.*

The division is attained by a resistance coil made to form part of a branch of the electric circuit, so that two separate branches of the same current pass one through the coil, the other through the light apparatus, and afterwards re-unite.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Aug. 13.		Business Done Week Ending Aug. 13. Highest.	Lowest.
Anglo-American	52¾,	53	52¾	52½
Do. "B"	81¼,	¾	82¼	81½
Do. "A"	26,	½	26½	26¼
Brazilian	6¾,	7	7 1-16	6 15-16
Cuba	7¾,	8¼	8	8
Do. Ten per Cent. Preference	15½,	16½	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11½,	¾	11¾	11⅝
Direct United States	10⅝,	⅞	10½	10⅝
Eastern	7¾,	⅞	7⅞	7¾
Do. Six per Cent. Debenture	105,	108	—	—
Do. Five per Cent. do	102,	104	102¾	102½
Do. Six per Cent. Preference	11 13-16,	15-16	12	11¾
Eastern Extension	7¾,	⅞	7⅞	7¾
Do. Six per Cent. Deb.	105,	108	105½	105½
German Union	7½,	8	—	—
Globe Telegraph and Trust	4 15-16,	5 1-16	5 1-16	4 15-16
Do. Six per Cent. Preference	11 1-16,	3-16	11¼	11⅛
Great Northern	8⅜,	⅝	8½	8⅜
Indo-European	21,	22	—	—
Mediterranean Extension	2¾,	3	2 15-16	2 15-16
Do. Eight per Cent. Preference	9,	½	9⅜	9¼
Reuter's	9,	10	—	—
Submarine	230,	235	—	—
West India and Panama	1¼,	½	1¾	1½
Do. Six per Cent. Preference	7½,	8	8	7 13-16
Western and Brazilian	3,	½	—	—
West. Union Seven per Ct. 1st Mt.	118,	122	—	—
Do. Six per Cent. Sterling	107,	109	—	—

TRAFFIC RECEIPTS FOR JULY, 1879.

Companies.	July 1879.	July 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,608	192	—
Direct Spanish Telegraph Company	913	812	101	—
Direct United States Telegraph Company	16,440	—	—	—
Eastern Extension Telegraph Company	23,411	24,927	—	1,516
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	20,421	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	725	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

ELECTROTYPE.—The Science and Art Department sends a series of electrotype reproductions of the regalia in the Tower to the Sydney Exhibition.

SYDNEY EXHIBITION.—The Telegraph Construction and Maintenance Company will exhibit specimens of their work at the International Exhibition at Sydney.

ELECTRICAL LITERATURE.—The *Philosophical Magazine* for the present month contains an article by John Kerr, LL.D., on "Electro-optic Observations on various Liquids," and two highly mathematical papers:—"On the Passage of the Galvanic Current Through Iron," by Felix Auerbach Ph.D. of Breslau; and "On the Theory of Faults in Cables," by Mr. Oliver Heaviside.

NEW FORM OF INSULATOR.—An insulator for telegraph wires, formed of a piece of glass perforated longitudinally, and a screw adapted to the perforation and having a round head provided with a square mortise for securing a key or screwdriver for driving the screw home, and having at each end a rubber ring, has been patented by Mr. J. H. Bloomfield, of Concordia, Entre Rios, Argentine Republic.

LOFTY TELEGRAPH STATIONS.—A telegraph station has been lately established at the Ryffel Hotel, under the Ryffelhorn, in the Valais. It is about 8,500ft. above the level of the sea, and is the highest telegraph station in Europe. A Swiss paper has claimed for it the pre-eminence of being the highest in the world. But this is not the case, for the station on Pike's Peak, in the Rocky Mountains, in the State of Colorado, is 14,000ft. above the sea level, and therefore something higher than that at the Ryffel Hotel.

THE ELECTRIC LIGHT AT BLACKPOOL.—The corporation of Blackpool have decided to light up the Promenade with six of Siemens' electric lights, representing 6,000 candle power, at a cost of £2,500. The light will be in operation in a few weeks time, and will be used every season for about twenty weeks. On the Thames Embankment the electric light exhibited only represents 300 candle power, so that there will be no comparison between the display there and at Blackpool. The corporation propose to spread the cost of the lights over ten years.

ESTIMATION OF CADMIUM BY ELECTROLYSIS.—Dr. E. F. Smith has succeeded in overcoming the objection to this mode of estimating cadmium, viz., that the metal is thrown down in such a form as to enclose impurities, by substituting the acetate of the metal for the chloride, previously used by Prof. W. E. Clarke. The metal was deposited upon the sides of a platinum crucible in the form of a crystalline grayish white layer; the positive electrode being a strip of platinum foil, and the battery two cells of Bunsen. Not the slightest trace of spongy metal was visible.

MAGNETS AND MILL WORK.—A thousand bushels of wheat were recently run through a spout of Washburn "B" mill, Minneapolis, which had been provided with magnets; and there were found adhering to them seventy-three pieces of wire and seventy-one pieces of other metallic substances, consisting of three tacks, two ends of cut nails, one end of horseshoe nail, and sixty-five pieces, small spawls of wrought iron, sheet iron, and cast iron, varying in size from $\frac{1}{8}$-inch to $\frac{1}{4}$-inch, in irregular shapes, many of them appearing to be scales or fragments broken from badly worn machinery.

NEW ALLOY.—M. Phillips has made some experiments for the determination of the coefficient of elasticity and of the limit of elasticity of different bodies. He refers especially to a new alloy which was melted and cast by Matthey, of London. Its density at the freezing point is 21·6139. Its composition is: Platinum, 80·660; iridium, 19·079; rhodium, ·122; iron, ·098; ruthenium, ·046. This alloy is so malleable and ductile that M. Sainte-Claire Deville possesses a thread of it, which is only a few hundredths of a millimeter in diameter and is scarcely visible. A hundredth of a millimeter is only $\frac{1}{2500}$ inch.

THE GAS LIGHT AND COKE COMPANY.—The fear from competition with the electric light expressed at some of the meetings of the gas companies not so very long ago seems to have subsided, and yet we should be inclined to say the competition will be a reality. At the last meeting of the Gas Light and Coke Company, the following paragraph was read in the report:—"The directors have before expressed an opinion with regard to the effect likely to be produced upon their undertaking by the electric light. That opinion remains unchanged, but, in the interval which has elapsed since it was commuuicated to the proprietors, the subject of lighting by electricity has been investigated by a Select Committee of the House of Commons, the results of whose deliberations, having been reported to the House and made public, it is now unnecessary to refer to more fully."

THE SHADOWS FROM THE ELECTRIC LIGHT.—A contemporary devoted to gas interests publishes the following letter. We call attention to it as a case of wilful blindness. Could not the writer see that the fault is not electrical? A second light would obviate such shadows. Trials of the electric light in machine shops should never be made with one light; two or three, so arranged that there could be no shadows, is what is required:—"It may interest some of those who watch the progress of this illuminant to learn the opinion of a director of a large manufactory, one of the first to adopt the new light. It was used in the casting shop, and gave a beautiful light, but when the steam crane intervened between the light and the workman the shadow was so intense as to render the light of no practical value. Add to this, he said, the fact that we need light in our wells, and you have our reason for returning to gas."

LIGHTING THE CAPITOL BY ELECTRICITY.—The *Scientific American* says that the arrangements for lighting the capitol building with a new electric light are nearly completed. The experiment has already been made in the hall of the House of Representatives, and a single light, placed on the front row of the reporters' gallery and over the Speaker's chair, made the whole hall so light that print could be easily read at the points furthest from the burner. The plan is to place four

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lights in the hall, and it is now believed that they will be a very great improvement upon the present arrangement of gas-burners. Three electric machines have been purchased under the appropriations for lighting the interior of the building, and it is in contemplation to place another in position for the purpose of supplying a light of vast power upon the top of the dome. It is claimed by the inventors that a burner can be constructed there which shall have a very appreciable effect upon a large area of the city. It is claimed that with the steam power of the heating and ventilating apparatus in each wing of the building a dynamo-electric machine of 175,000 candle power can be run.

TELEGRAPHY IN FRANCE.—By the end of the present year, of 87 chief towns of departments, only 26 will not be provided with direct communication with Paris. These 26 communicate through intermediate offices. There are other towns besides these in direct communication with the capital, the total number of direct wires to provincial centres being 113, and several of these centres have more than one such wire. Amiens has two; Bordeaux, two; Brest, two; Havre, two; Lille, two; Lyons, three; Marseilles, four; Montpellier, two; Nantes, two; Toulouse, two; Trouville, two; and Versailles, 39, of which 25 are subterranean. As regards direct wires to foreign centres, Paris has one to Amsterdam, one to Antwerp, one to Basle, three to Berlin, one to Berne, one to Bregenz, three to Brussels, one to Cologne, one to Florence, two to Frankfort, one to Geneva, nine to London, one to Metz-Hamburg, one to Milan, one to Mülhausen, one to Rome, one to Strasburg, one to Turin, and two to Vienna. There is also a direct submarine wire from Marseilles to London. Since the reduction of the telegraph tariff the number of telegrams sent has increased over 50 per cent.

MALLEABLE NICKEL AND COBALT.—Th. Fleitmann has succeeded in obtaining the metals nickel and cobalt in malleable condition by fusing them with a very small quantity of metallic magnesium. He suspected that the absorption of carbon monoxide by the metals might be the cause of their want of malleability, and introduced the magnesium for the purpose of destroying the gas, as this metal is known to decompose the oxides of carbon. The success was very surprising. An addition of one-eight per cent. of metallic magnesium changes the structure of the metals entirely. They can now be easily welded when hot. Nickel is malleable even when cold, while cobalt becomes extremely hard when cold, so that it will probably be applicable for cutting instruments. At the same time the cast metals are very compact, and are almost as solid and tough as cast steel, so that the metallic parts of harness and similar objects may be made from them. Both metals take a very high polish, and resist the action of the atmosphere very well. The author has also succeeded in welding malleable nickel and cobalt together with steel and iron, so that the pieces of iron and steel that are coated on one or both sides with nickel or cobalt may be beaten out to the thinnest plates without any separation of the metals.

MAGNETISING MOLTEN IRON.—In a letter to Dr. C. W. Siemens, and communicated by him to the Society of Telegraphic Engineers, Mr. E. Chernoff records a very curious experiment. Believing that, if it were possible to magnetise white cast iron, a magnet of greater permanence than any made of steel would be obtained, Mr. Chernoff cast some white refined iron in a mould, surrounded by an electro-magnetic reel, along which a current was allowed to flow during the process of casting, so that the fluid metal became magnetic, and cooled under the influence of the magnetic current. The result so far justified the expectation as to give a magnetised bar of white cast iron; but the form of the bar was unlike what was expected. While pouring the metal into the mould and until the metal set, Mr. Chernoff observed a singular agitation of the metal, which could not have proceeded from damp, as the mould was thoroughly dry. On cooling, the bar proved to be hollow; the cavity being symmetrical and extending about two-thirds the length of the bar. The metal was thinnest just opposite the centre of the reel, where it did not exceed the thickness of writing paper. The agitation of the metal in cooling is accounted for by the repulsion of the molten metal toward the poles of the magnet. By casting under pressure it may be possible to obtain by this method extremely permanent and powerful magnets of white iron. Possibly also this experiment may lead to some useful modification of industrial processes for casting hollow cylinders without cores.

DEPOSIT ON GLASS ENCLOSING AN ELECTRIC LIGHT.—Mr. B. S. Proctor writes as follows in the *Newcastle Chemical Society's Journal*:—"At our meeting in December, 1878, Mr. J. W. Swan exhibited an electric lamp, on the incandescence principle, which had broken down in consequence of the electric force being too great for the cylinder of carbon through which it had to pass. One of the points of interest noted was the appearance of a sooty deposit on the inside of the glass. The flask which contained the carbon pencil and its platinum conductors, having been filled with nitrogen and exhausted with a Sprengel pump, was supposed to contain nothing which could act as a carrier to convey by chemical means any carbon from the incandescent pencil to the cooler surfaces in its neighbourhood. The phenomenon appeared to be such as has been spoken of under the term 'volatilisation of carbon.' Mr. Swan having placed the lamp at my disposal for examination, I have now the pleasure of bringing under your notice the results. Under the microscope the smoky deposit on the glass showed numerous bright globules, no doubt platinum, and more minute particles of dark matter nebulous under a quarter inch objective. A fragment of the glass being exposed to an oxidizing heat, the deposit partially disappeared, still leaving the glass slightly darkened. The platinum support—which had also a coating of dark sublimate at a little distance above and below the carbon pencil but not in immediate juxtaposition with it—was next examined by exposing to the blowpipe flame the unsmoked portion, so that the conducted heat might act upon the deposit without the fear of the blast carrying away the matter, which was very loosely attached. In this way the deposit was burnt off without the mechanical action of the blast, the heat to which it had been subjected being that of dull redness. A piece of the glass was then treated with *aqua regia* for several days. The deposit was diminished, but far from being entirely dissolved; the solution gave a blue reaction with yellow prussiate of potassa, and no coloration with tannin till aided by vapour of carbonate of ammonia, when the usual purple colour of ferric tannate was developed. There is thus evidence of the deposit containing platinum, carbon, and iron. Probably the scattering of platinum globules might result from the disruptive discharge which took place at the moment of the lamp breaking down."

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CONTACT THEORY OF VOLTAIC ACTION.

PARTS I AND II.

By W. E. AYRTON and JOHN PERRY, Professors in the Imperial College of Engineering, Tokio, Japan.

Communicated by Professor Sir W. THOMSON, F.R.S., to the Royal Society.

PART I.

I.

The contact theory of voltaic action seems to have undergone no development since the date of Sir W. Thomson's experiment, which consisted in connecting a plate of zinc and a plate of copper by means of a drop of water, when it was found that the metals were brought to the same electric potential, although when metallically connected they were at different potentials. He believed that any electrolyte would behave in exactly the same way as the water of his experiment, equalising the potentials of any two metals connected by it. The electromotive force of a simple cell, ought, in accordance with the theory, to be equal to the difference of potentials between zinc and copper in contact. A test founded on this deduction was very difficult to apply, because there was no exact determination of the difference of potential of zinc and copper in contact, Sir W. Thomson, in his experiment, having really measured the difference of potential between air at the surface of a zinc plate, and air at the surface of a copper plate. In the absence of this test, the equality of the electromotive forces of simple cells in which zinc and copper are the metals (the liquids being water, dilute sulphuric acid, and sulphate of zinc) was held as a proof of the theory. Now it is known that when two pieces of the same metal are dipped into any two liquids, which are diffusing into one another, a difference of potentials is established between the metals, and the electromotive force of a cell of this kind can in no way depend on a difference of potentials due to metallic contact. So that although in such a cell there is an action which is somewhat the same as the action in a simple voltaic cell, the theory took no account of it whatever. It must not, therefore, be supposed that the lead-copper cell described by Mr. Fleming in his Paper given to the Physical Society proved or disproved the contact theory of voltaic action, since it took into account the difference of potentials at the contact of a solid and liquid, which was not contemplated by the contact theory as ordinarily stated. In fact, the explanation of voltaic action given in the latest treatises on electricity is felt to be incomplete, even by the writers of such treatises, and the present investigation has been entered upon in consequence.

Sir W. Thomson's result, and our own experiments lead us to imagine that when zinc and copper are immersed in water there are three successive states to be noticed:—At the instant of immersion the zinc and copper may be reduced to the same potential, so that the electromotive force of the voltaic cell E is equal to the difference of potential $\overline{ZC}$ between zinc and copper in contact; the zinc now becomes negative to the copper, so that E reaches a limit which is greater than $\overline{ZC}$; lastly, if a current passes, polarisation occurs and the zinc becomes gradually less negative to the copper, E diminishing, therefore, from its maximum value. But when a saturated solution of zinc sulphate is employed instead of water, the first state, if it exists at all, exists for so short a time that practically zinc and copper in zinc sulphate are never at the same potential. Thus (see Table X) when care is taken to keep the zinc and copper in a water cell well insulated from one another, E is found to increase from a value very little greater than $\overline{ZC}$, the electromotive force of contact of zinc and copper, to a limit, but in a zinc sulphate cell no such great increase is observed.

In our present experiments we are not concerned with instantaneous electromotive forces of contact, a short time elapsing in every case between the contact and the determination of its electromotive force; and with polarisation in the ordinary sense we have equally no concern. In fact, our experiments relate to the maximum electromotive forces of simple and compound cells.

We find that zinc and copper connected by the electrolyte zinc sulphate, dilute sulphuric acid, or water are not at the same potential, the zinc being negative to the copper. In the case of dilute sulphuric acid, where polarisation cannot be prevented, the negative charge of the zinc rapidly diminishes, so that there is an instant at which the metals are reduced to the same potential; from Sir W. Thomson's result we may suppose that there are two such instants.

We did not measure the potentials of the surfaces which we mention but really of air in the neighbourhood of these surfaces. [At the time this Paper was originally published we thought we had reason for believing that the difference of potentials between a substance and the air in contact with it was small, but as explained in our third Paper on the Contact Theory of Voltaic Action, communicated some months back to the Royal Society, this difference of potentials may constitute at times the larger portion of what is measured].

Our experiments show, but not with as much accuracy as might be desired, that the electromotive force of contact of two metals or two electrolytes, or of a metal and an electrolyte, is in each case a constant; that is to say, if $\overline{AB}$ means the electromotive force of contact of the metal or electrolyte A, and the metal or electrolyte B (measured when A and B are not in contact with other conducting substances), $\overline{AB}$ being identical with $-\overline{BA}$; then the total electromotive force of any closed heterogeneous circuit composed of the substances A, B, C, N is:—

$$\overline{AB} + \overline{BC} + \&c. + \overline{NA}.$$

The proof of this law is very important, as it is often denied without experimental data. Professor F. Jenkin says:—"The following series of phenomena occur when metals and an electrolyte are placed in contact: 1. When a single metal is placed in contact with an electrolyte, a definite difference of potentials is produced between the liquid and the metal. If zinc be plunged in water, the zinc becomes negative, the water positive. Copper plunged in water also becomes negative,* but much less so than zinc. 2. If two metals be plunged in water (as copper and zinc), the copper, the zinc, and the water forming a galvanic cell, all remain at one potential, and no charge of electricity is observed on any part of the system."

It will also, we think, become evident that the natures of the metals and of the electrolytes determine the electromotive force of a voltaic cell, just as the natures of the metals and the distribution of temperature determine the electromotive force of a thermo-electric arrangement, and as the nature of the two metals, zinc and copper, determines the electromotive force of Sir W. Thomson's mechanical cell, in which copper filings fall from a copper funnel through a zinc inductor, in metallic connection with the copper, into a copper vessel.

II.

At the surface of contact of two conducting substances there is an electromotive force of definite amount, which tends to make electricity flow from one of the substances to the other. For instance, at the junction of zinc and copper there is an electromotive force of 0·75 volt, which tends to cause electricity to flow from the copper to the zinc across the junction. This flow ceases when the potential of the zinc is 0·75 volt greater than that of the copper, the difference of potentials of the metals balancing the electromotive force of the junction. It is this difference of potential which is measured by the apparatus which is described below. When a substance, M, is said to have a higher potential than a substance, N, in contact with it, we mean that this state has been established in virtue of an electromotive force which exists at the junction of the substances, and that the electromotive force of contact tends to produce a current of electricity from N to M across the junction.

Sir W. Thomson's method of measuring the difference of potential between two metals in contact, which consisted in hanging a needle symmetrically over two similar plates of different metals, and observing its deflections when it was charged, first positively and then negatively, requires, in order to be accurate, all the delicacy of the arrangement and even more complicated contrivances than those employed in the quadrant-electrometer. It will be easily seen that a series of experiments for determining the difference of potentials between pairs of metals, pairs of liquids, and between liquids and metals, could only with the very greatest difficulty be carried out by a method which virtually requires the taking to pieces and refitting of a quadrant-electrometer for every experiment. The authors' attention was, therefore, directed to devising a method of investigation in which a delicate quadrant-electrometer would be employed to measure the difference of potentials between two similar metal plates, themselves acted on inductively by parallel and equidistant plane surfaces of the two substances in contact, the difference of potentials between which it was desired to measure. Thus, let A and B be two insulated brass plates connected with the electrodes of the electrometer. Let C under A and D under B be the surfaces whose difference of potential is to be measured. A and B are both put to earth and then insulated. C and D are made to change places with one another, C now being under B and D under A. The deflec-

* We found that copper is positive to distilled water, zinc being negative to the water.

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tion of the electrometer needle will now give a measure of the difference of potential between C and D.*

The apparatus, by means of which our idea has been carried out, has, by a process of natural selection, assumed the form shown in Plate 7. The circular brass plates A and B, 20·4 centims. in diameter, are supported and kept insulated by means of artificially dried glass stems. The leaden cups J, containing pumice stone moistened with sulphuric acid, slide in H by a bayonet joint, and may be lowered by the handles I so as to rest on the brass plates when the instrument is not in use, thus preventing access to H of the external air.

The permanent adjustment for coincidence of the plane surfaces of the brass plates is effected by means of three wood-screws in each of the brass caps K; temporary adjustment for horizontality of the brass plates is effected by means of a spirit level and three levelling screws T T, which support the wooden frame W P W′, and the positions of which on the three wooden blocks T′ are fixed by "hole, slot, and plane." One of these levelling screws has been removed in the drawing to show the lifting arrangement.

F and G are strips of brass soldered to the plates A and B, and connected by means of clips to wires leading to the insulated electrodes of the quadrant electrometer, and to the insulated screws A′ B′ of the short-circuit key.

In the drawing† we have shown the apparatus as arranged for determining the electromotive force of contact between a metal, D, and a liquid, C. V S is a screw-jack which enables the oblong wooden table O S′ O′ to be raised to any level, and the table may be turned round horizontally at any level. Three levelling screws, working in nuts in the table, support the metal plate D, and three others, exactly similar, support the porcelain vessel G which contains the liquid, so that the upper surfaces of both C and D are in the same horizontal plane. A binding screw, *a*, is soldered to the plate; in the present case it holds the metal strip E, which makes contact with the liquid. E must have been cut from the same sheet as the plate D. When there are two vessels of liquid, contact is made between the liquids by wetting a piece of cotton wick in one of the liquids and allowing its ends to dip below the liquid surfaces.

The brass rods N′, insulated where they pass through the wooden frame by glass tubes and bone washers, are gauges which may be lowered or raised until their ends are at fixed distances below the level of the plates A and B. By the reflections of these ends at the surfaces of the liquids or plates, we can judge of the position of the level surfaces C and D. The wooden pegs O and O′, and a vertical slot in the stand at W″ W‴, enable a reversal of C and D to be made with accuracy and rapidity.

The parts of the frame W′ W″ W‴ in view of the brass plates are covered with tin plates or tin foil, connected with the outside of the electrometer. A tin plate door, of which the hinges are seen at M M, shuts up a metal box enclosing the whole apparatus, including the electrometer, short-circuit key, and connecting wires. This box is permanently in connection with the outside of the electrometer. The plug Z of the short-circuit key is kept connected with this cover through a hole in which it may be withdrawn from its bed to insulate the plates.

We shall now describe a complete operation, to obtain the electromotive force of contact between a metal and a liquid, for example. Suppose the permanent adjustments to have been made, and that the plates A and B are quite bright. The plate D is cleaned and laid on the levelling screws R; the porcelain dish containing the liquid is laid on the levelling screws Q. By turning S and the levelling screws (O moving in its slot), and by the use of a gauge *g h*, of which the *h* part represents the distance apart determined upon for A and C and B and D, we get the surfaces into their proper relative positions. The brass rod N′ is now lowered until its end and its reflection at the surface of D seem to meet, and it is then made fast. Before proceeding further, the insulation of the glass rods, the permanence of the zero of the electrometer, and the permanence of position of the needle when the quadrants are insulated, are ascertained. The strip E, which is quite bright, is now bent to dip into the liquid, and the cover M is lowered. Insulate by means of the key, and take the zero. Now lift the cover M, lower the table, and reverse C and D; raise the table until the end of N and its reflection in the surface of the liquid nearly meet; lower the cover, and take a reading. Now short-circuit the quadrants, insulate, and proceed to take a new reading. Alternate readings are on opposite sides of the zero.

We found that when slight changes occur in the dryness of the air inside the electrometer, there are changes in the zero which are probably due to slight traces of moisture remaining on the suspension fibres of the needle. It is also to be remarked that when the quadrants of the electrometer are insulated from one another, any slight change in the charge of the instument causes a motion of the needle.

The hand must be trained to insulate the plates from one another. After three months' practice our insulations are so perfect that there is seldom even a tremor on removing the plug, whereas in the beginning of our experiments we often had in succession ten bad attempts at insulation. A good insulation depends on the plug leaving both sides of its seat simultaneously. This key gave better results than any of the other arrangements at our disposal.

We at first thought, from considering the change of capacity in the quadrants (as the needle moved), that our measurements would be more accurate when very small. This is not the case, but it led us to try a method of observation which may suggest itself. We brought the spot of light to zero in every experiment by acting inductively on the insulated plates A and B by means of small plates placed over them charged to a measurable difference of potential. We may employ this method modified at some future time.

The suspension fibres of the needle were tolerably near one another, and the trap-door gauge was adjusted for as great a charge as it was convenient to give to the jar, and as it was nearly unstable it indicated extremely small changes of charge. The relative positions of the mirror G, the lamp, lens, and scale* are shown in the lower right-hand part of the Plate. The lens forms a virtual image of the wire of the lamp-slit at 60 centims. from the mirror G′, and the scale I,* which is two metres from the electrometer, receives the image formed by the mirror. We had supposed that no better definition of the slit could be obtained by the use of a lens, but in reality great benefit was derived from its use, our readings being much more accurate than they would have been had the lamp-slit, without the lens, been put at 60 centims. from the mirror. We consider that our readings (as far as the electrometer itself is concerned) are fairly accurate to the one two-thousandth part of a volt.

III.

To find the relative values of deflections of the electrometer needle, two brass plates were placed under A and B at the distance of 6·4 mm. We were able to give to the plates a difference of potentials equal to the electromotive force of a Daniell, or to any fraction of this. Reversal is made by means of a key without any actual changes in the positions of the plates.

TABLE I.—9th March, 1876. Plates 6·4 mm. apart.

One Cell.

Zero.	Reading.	Deflection.
1058·0	1127·3	69·3
56·9	990·0	66·9
59·9	1129·8	69·9
64·0	997·0	67·0
65·0	1134·0	69·0

* Suppose C and D to be very large, and that the protecting covering of the apparatus is far away from the insulated plates. Let the coefficients of induction of the two sets of quadrants, when there is a difference of potential, d, between them, be $s + dm$ and $s - dm$. We know from the position and shape of the needle that this is approximately true. Let a be the area of each of the insulated brass plates A and B; t the distance from A to C or from B to D. Let α be the potential of the surface C, and $\alpha + v$ the potential of D at the beginning of the experiment. When A and B are connected to earth, the charge on A and its electrometer-quadrants is $-\frac{a\alpha}{4\pi t} - sV$, V being the potential of the needle. The charge on B and its quadrants is $-\frac{a(\alpha + v)}{4\pi t} - sV$. After reversal, if C has a potential γ and D, therefore, a potential $\gamma + v$, the charge on A and its quadrants is $\frac{a(V_A - v - \gamma)}{4\pi t} + \{s - m(V_A - V_B)\}(V_A - V)$, and the charge on B and its quadrants is $\frac{a(V_B - \gamma)}{4\pi t} + \{s + m(V_A - V_B)\}(V_B - V)$, where V_A and V_B are the potentials of A and B respectively. Equating the respective charges before and after reversal, and subtracting, we get

$$(V_A - V_B)\left(\frac{a}{4\pi t} + s\right) - m(V_A^2 - V_B^2) = \frac{2av}{4\pi t}. \quad . \quad . \qquad (1)$$

If we might neglect the change of capacity of the quadrants, we should have

$$v = \frac{(V_A - V_B)\left(\frac{a}{4\pi t} + s\right)}{\frac{2a}{4\pi t}}. \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

So that v varies as $(V_A - V_B)$.

Now our experiments show this to be the case, and consequently (2) gives the correct value of v.

† This drawing will be reproduced as a woodcut with the second instalment of the Paper in our next impression.—ED. *E.*

* Not represented in the Plate.

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Zero.	Reading.	Deflection.
1067·1	1000·0	67·1
68·0	1136·6	68·6
68·4	1000·0	68·4
68·6	1137·0	68·4
69·2	1001·5	67·7
	Mean..................... 68·2	
	0·9 of a Cell.	
1074·0	1138·0	64·0
73·0	1016·0	57·0
72·0	1135·0	63·0
71·0	1011·1	59·9
68·9	1129·8	60·9
67·1	1004·9	62·2
64·0	1125·0	61·0
62·8	1001·0	61·8
61·2	1122·5	61·3
60·1	998·5	61·6
59·6	1120·0	60·4
60·0	1000·0	60·0
60·0	1121·0	61·0
	Mean..................... 61·1	
	0·8 of a Cell.	
1063·5	1007·5	56·0
64·1	1119·1	55·0
65·2	1010·0	57·2
65·8	1121·0	55·2
67·0	1012·2	54·8
67·5	1123·2	55·7
	Mean..................... 55·3	
	0·7 of a Cell.	
1070·0	1022·0	48·0
70·1	1119·0	48·9
71·1	1024·0	47·1
72·0	1121·5	49·5
73·0	1025·0	48·0
73·0	1121·5	48·5
73·8	1025·0	48·8
73·5	1122·0	48·5
	Mean..................... 48·4	
	0·5 of a Cell.	
1073·0	1039·0	34·0
73·0	1107·2	34·2
73·0	1038·1	34·9
72·8	1107·5	34·7
72·3	1038·0	34·3
	Mean..................... 34·4	
	0·4 of a Cell.	
1068·9	1096·0	27·1
68·0	37·0	31·0
67·1	94·1	27·0
67·0	38·2	28·8
66·8	94·0	27·2
66·3	38·5	27·8
66·0	92·5	26·5
66·0	37·1	28·9
65·6	92·0	26·4
65·8	37·5	28·3
	Mean..................... 27·9	
	0·3 of a Cell.	
1066·1	1086·4	20·3
66·1	45·0	21·1
66·1	86·0	19·9
66·1	45·0	21·1
66·9	87·0	20·1
67·0	45·5	21·5
66·3	86·0	19·7
68·1	46·0	22·1
	Mean..................... 20·7	
	0·2 of a Cell.	
1069·0	1082·2	13·2
69·0	54·1	14·9
68·0	81·0	13·0
67·2	52·5	14·7
66·6	80·0	13·4
66·8	52·0	14·8
	Mean..................... 14·0	
	0·1 of a Cell.	
1063·0	1056·0	7·0
64·0	70·6	6·5
65·0	57·8	7·2
65·5	71·6	6·1
64·8	56·5	8·3
63·4	69·1	5·7
	Mean..................... 6·8	

Taking fractions 0·1, 0·2, &c., of 68·2, which is the mean deflection representing the electromotive force of a whole cell, we get the numbers A of Table II. The numbers B are the means of Table I.

TABLE II.

A..............	6·8	13·6	20·5	27·3	34·1	47·7	54·6	61·4	68·2
B..............	6·8	14·3	20·7	27·9	34·4	48·4	55·3	61·1	68·2

Thus the deflections are proportional to the differences of potential between the lower plates, a result which could not have been anticipated. At the distance of 16 mm., the results given in Table III. were obtained, and here again we find that the deflections are proportional to the difference of potential between the lower plates.

TABLE III.—9th March, 1876. Plates 16 mm. apart.

Zero.	Reading.	Deflection.
	One Cell.	
1065·1	1093·0	27·9
61·8	23·5	38·3
59·5	91·5	32·0
60·6	26·5	34·1
61·3	96·0	34·7
62·8	27·8	35·0
62·2	94·1	31·9
64·9	31·5	33·4
64·7	98·0	33·3
62·1	24·5	37·6
	Mean..................... 33·8	
	0·5 of a Cell.	
1064·0	1080·1	16·1
64·6	45·8	18·8
57·1	70·8	13·7
57·0	37·5	19·5
	Mean..................... 17·0	

It was not necessary to prove the law of proportionality for other distances than 6·4 and 16 mm.

TABLE IV.—9th March, 1876. Plates 10·9 mm. apart.

Zero.	Reading.	Deflection.
	One Cell.	
1055·5	1101·5	46·0
57·0	1006·6	50·4
55·8	1100·6	44·8
56·2	1005·5	50·7
56·1	1100·0	43·9
55·0	1002·0	53·0
53·4	1098·5	45·1
54·0	1004·0	50·0
	Mean..................... 48·0	

The Daniell was occasionally connected with the electrometer directly. It constantly gave the deflection 230·4. It was not a new Daniell. Thus the ratio between the deflections obtained by two methods of measuring a difference of potential, one by direct connection with electrometer, and the other by reversing the induction plates, is 3·4, when the distance between the plates is 6·4 mm., 4·8 for 10·9 mm., and 6·8 for 16·0 mm. Plotting three points on squared paper with these numbers as co-ordinates, and drawing the arc of a circle through them, we found the approximate values of the ratios corresponding with different distances given in Table V. This table was useful in showing how any error in adjusting the plates affected the deflection.

TABLE V.

Distance in millimetres	6	7	8	9	10	11	12	13	14
Ratio	3·30	3·55	3·84	4·13	4·48	4·83	5·21	5·62	6·05

In subsequent experiments we used the distances 10·9 and 10·0 mm. As the electrometer was twice taken to pieces, its quadrants being altered in position, we took great care in the later experiments to determine the value of our deflections in each case.

(TO BE CONTINUED.)

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THE BRITISH ASSOCIATION.

On Wednesday, August 20th, 1879, the British Association met at Sheffield for its forty-ninth session. The first meeting of the Association was held at York in 1831, under the presidency of the Earl Fitzwilliam, and since then it has visited the shire four times, namely, at York again in 1844, at Hull in 1853, at Leeds in 1858, and at Bradford in 1873. The number of members at these dates were respectively 353 in 1831, 876 in 1853, 1,698 in 1858, and 1,983 in 1873. If the number in 1879 shows a similar increase, the funds of the Association will not suffer from its first visit to Sheffield; and if we know Sheffield aright, there will be no diminution of interest at this meeting. Hallamshire is the centre of a district which has shown a determination to do things thoroughly. Sheffield interpreted the Education Act in a liberal spirit, and its School Board is one of the best conducted in the country. Under its auspices the Frith College will shortly be opened, and is expected to form a connecting link between the National School and the Grammar School. Turning from the educational to the practical, Sheffield is the centre of certain steel manufactures, and has long held the first place in its own particular line. Its citizens are not the men to take a thing in hand and allow it to fail, and therefore we expect this meeting of the British Association to be more than ordinarily successful. The local secretaries are H. Clifton Sorby, F.R.S., well known as one of the foremost, if not the foremost, of living microscopists; and J. F. Moss, the energetic secretary of the School Board, a gentleman whom we know from experience to possess remarkable administrative talents. It is not our intention to enter into a history of Hallamshire, that will be given in the local and other papers, or to dwell further on its peculiar fitness as a meeting place of the British Association.

A glance at the report issued by the Association last year will show that some work of an electrical character was contemplated, and we may hope that this year the reports will be ready. In the first place, a Committee was appointed for the purpose of making certain observations on atmospheric electricity at Madeira. This Committee consisted of Profs. J. D. Everett, G. Forbes, and Sir W. Thomson. A Committee, consisting of Messrs. Ayrton, Gordon, and Lodge, was appointed for accurately measuring the specific inductive capacity of a good Sprengel vacuum. Prof. W. S. Adams, Mr. J. T. Bottomley, Mr. W. M. Hartley, and Mr. J. M. Thomson undertook to investigate the law of the "Electrolysis of Mixed Metallic Solutions and Solutions of Compound Salts." The Association voted money grants for the pursuit of these investigations. The papers, however, embodying the results of these investigations are but few compared with those sent in by experimentalists who prefer to remain unfettered even by an implied promise to work in certain directions, and who are led frequently by unforeseen results whilst performing other experiments. Others, and these principally young workers in the field of Science, determine to pursue a certain line of investigation through the year, in the hope that careful research may lead to something worthy of a place in the records of the Association. We think this is one of the most valuable influences of the Association and of kindred societies. It induces men who would not otherwise work to continue their labours; it induces young men to work for a settled purpose; and it brings young and old together to discuss the results of their labours.

One of the features of this meeting will be the collection of scientific apparatus, which has been obtained by the exertions of Messrs. Knox and Pye Smith. Among the exhibits will be found some new apparatus for the determination of specific inductive capacity, devised by Mr. J. E. H. Gordon, who has long been engaged upon this important work. A miniature static induction balance, intended specially for determining the specific inductive capacities of crystals along and across the axis, and other instruments for these investigations are among these exhibits. Mr. Crookes has promised to show some of his experiments on molecular physics in high vacua. Mr. Louis J. Crossley, of Halifax, shows his telephone transmitter in conjunction with a Bell telephone as receiver. Mr. Hunnings also shows an improved telephone, and Messrs. Tasker and Co. show the telephonic arrangements so largely adapted in America to a central system of

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telephonic exchange. As there seems some probability of the system taking root in England, it may be interesting to know that in Cincinnati the Exchange numbers some six or seven hundred subscribers. The system permits any subscriber to speak directly to any other subscriber with whom he desires to communicate.

Mr. E. Cowper exhibits his telegraphic writing instrument, Mr. Fellows his multiplex apparatus, Messrs. Horne and Thornthwaite and others send interesting apparatus of an electrical nature. Among the exhibits of a non-electrical character will be found Professor W. E. Ayrton's collection of Japanese mirrors.

We are not amongst those who think that learned societies have had their day and that the increase of technical publications derogates from the possibility of any new thing being discussed at the meetings. The reports obtained, the work initiated by the British Association proves the contrary, though when a society degenerates into becoming a mere advertising machine by means of its papers we agree that adverse criticism is deserved. Hitherto the British Association has steered clear of such pitfalls, hence it deserves our heartiest support.

The proceedings were opened on the above-mentioned date, in the Albert Hall, by an address from Professor Allman, M.D., LL.D., F.R.S., the President, on the subject of protoplasm and living matter generally. The results of recent investigation were given with as little technicality as possible; and towards the close of his address he discussed the question whether the powers of the mind could be conceived as properties of living matter, but decried the broad tempting generalisation that there is nothing in the universe but matter and force.

CORRESPONDENCE.

A THERMO-ELECTROLYTIC COUPLE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: A brief description of the following experiments may be of interest, especially to those of your readers who can find time to repeat and extend them.

I took the lid of a tinned iron canister, attached a wire to its rim, and placed it with the rim upwards on the ring of a retort-stand. Then, after placing three small fragments of glass on the bottom of this small metal tray, (in order to prevent contact with the metal surface to be placed within it) I half filled it with carbonate of potash, to which was afterwards added sufficient water to liquify the salt. A canister of the same material, of smaller diameter than the lid, had also a wire attached to it; it was then filled with cold water, and immersed in the potash salt. On connecting the two wires with a galvanometer of moderate sensitiveness, no deflection was produced. But on applying the flame of a spirit lamp to the bottom of the tray, the galvanometer needle was gradually deflected until it reached the stops. Resistance was then inserted in the circuit, and it was found that its effect in reducing the deflection was small in comparison with that produced in the case of an ordinary thermo-couple; from which it was to be inferred that the electromotive force of the electrolytic couple is comparatively high. The EMF was in fact found to be nearly ·3 ohm.

With the potash solution, the heated surface constitutes the positive element of the couple, *i.e.*, the wire attached to it is the negative pole. But with some other solutions, *e.g.*, nitrate of ammonium, the heated surface constitutes the negative element. It was found that the deflection diminished as the water in the canister became heated: there was also a gradual diminution of current which was apparently due to "polarisation" of the negative element, since an increase of current was obtained after this element had been exposed for a short time to the air.

The question presented itself whether the effect was independent of chemical action upon the heated surface, which was found to be attacked: it was also of importance to employ some means to obviate polarisation. I therefore pierced a hole in the bottom of a porous jar, of sufficient size just to admit of the passage of a tube of silver, long enough to reach to the top of the jar; silver being a metal which is not appreciably acted upon by alkalies. This tube was to constitute the positive element, and to form a kind of chimney for the flame of the spirit lamp. The negative element was a silver wire, wound upon the exterior surface of the porous jar. Both elements were furnished with wires by means of which they could be connected to a galvanometer. On filling the latter with moistened carbonate of potash, and placing the flame of the lamp within the lower extremity of the silver tube, a current was obtained, about equal to that observed in the case of the elements of tinned iron. This current, however, became greatly weakened by the heating of the silver wire constituting the negative element, and also probably by the effect of the heat in drying the outer surface of the jar; and for this reason means were devised to cause a stream of water to flow continuously over this surface. The current was then maintained nearly constant for many hours at a time. Press of work in other directions has prevented me from continuing the investigation of these phenomena, which may possibly lead to the construction of a new thermo-generator of electricity.—Yours, &c.,

Desmond G. FitzGerald.

ON THE USE OF BATTERIES FOR SMALL ELECTRIC LIGHTS.*

Excepting in courses of physical science, the use of the battery for the production of the electric light by means of regulators is almost completely given up. Experience has at the present day decisively established the superiority of machines from the point of view of the cost of working.

Still, there are many persons who think of employing the battery for the production of small lights, more especially with lamps constructed for incandescence. With 6 or 8 flat Bunsen cells, 20 centimetres in height, costing at present 12fr. each, or 96fr. for the maximum, it is possible to maintain during three hours a light equal to from 8 to 10 carcel burners (*becs*). Such a result, however tempting it may be to the amateur, does not afford grounds for the use of the battery in industrial applications.

The following figures leave no doubt as to this matter.

Expense of a Bunsen battery, Rhumkorff model, of 8 elements. Luminous intensity, 10 *becs*. Duration of the light, 4 hours at the outside.

Nitric acid, 4 kilog	3fr. 20c.
Sulphuric acid, 1kilog. 200gr.	0fr. 36c.
Mercury, 100gr.	0fr. 60c.
Zinc (waste included), 400gr.	0fr. 40c.
Maintenance, breakage, mounting, &c.	1fr. 20c.
Total	5fr. 81c.

Or 1fr. 45c. per hour, and per *bec* per hour 0fr. 14·5c.

We must not forget that the Bunsen battery is most disagreeable to use, in consequence of the production of nitrous gases, which poison the air and act upon everything they come into contact with.

The only batteries which have to be considered besides that of Bunsen are:—Bichromate batteries, successfully used in electro-deposition; Thomson batteries, recently imported from England by M. Niaudet, and experimented with at the Collège de France by M. Mascart for working electro-magnetic machines; the Faure battery, a kind of modified Bunsen; lastly, the rotary battery of Bequerel, well known to physicists, although not in use.

THE FAURE BATTERY.

This is composed of a porous bottle made of agglomerated graphite, closed with a carbon stopper, and of an ordinary cylindrical zinc element, surrounding the bottle without touching it. Nitric acid is put in the bottle, and the zinc is surrounded with acidulated water. The couple thus mounted acts like an ordinary Bunsen, without sensible evolution of nitrous gases;† but the production of electricity is very weak. Eight couples, carefully mounted, were unable to raise to incandescence the end of a carbon rod 1 millimetre in diameter.

THOMSON BATTERY.

The battery experimented with was composed of 12 couples, of which the zinc and copper surfaces were 200 × 200 millimetres.

* Translated from the *Révue Industrielle*.

† We should say that it acts very *unlike* an ordinary Bunsen, and much more economically; the gas evolved being mainly N_2O_2 instead of N_2O_4 — Ed. *E.*

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The electrodes and the liquids were separated by a square tray of parchment paper, and by wooden blocks about 4 mm. thick.

These 12 couples attached to an incandescent lamp with carbons 1 mm. in diameter gave a white but extremely weak light (? 1 candle). The internal resistance must, therefore, be very great, in spite of the size and proximity of the electrodes.

We calculate that, in order to obtain a current equivalent to that from the 8 Rhumkorff couples, at least 45 Thomson couples on the model we used would be required, which would be expensive to purchase and somewhat cumbersome.

The expense for 4 hours would be about:—

Zinc (including waste) 700 grammes	0fr. 70c.
Sulphate of copper 1 kilo. 500 gr.	1fr. 65c.
Maintenance (porous trays, &c.)	0fr. 35c.
Mounting and unmounting (partly covered by the reduced copper)	0fr. 30c.
Total	3fr. 00c.

Say 7fr. 5c. per hour per *bec*.

This battery is very constant, emits no odour, and could work for over 12 hours without being recharged. On the other hand, its first cost is high, and it is cumbersome. Although more economical than the Bunsen, its expense is still too great to allow of its being utilised for currents in electric lighting.

BICHROMATE OF POTASH BATTERIES.

A trough battery of 15 couples (5 in series and 3 for quantity), designed by M. Ducretet and M. Loiseau, did not give good results. The light, tolerably vivid at the moment of immersing the elements, almost immediately began to fall off. At the end of ten minutes considerable polarisation had occurred, reducing the light to about ½ *bec*. By withdrawing the couples from the fluid they become almost instantaneously depolarised. Agitating them within the fluid produces a partial depolarisation which allows of the experiment being continued longer than when they are at rest.

This battery, costly, cumbersome and very inconstant, could be used only for experiments of very short duration.

BATTERIES WITH POROUS VESSELS.

Eight Rhumkorff couples were tried with the following exciting fluids in succession:—

1. Le Gourant de Tromelin element.

Interior vessel (carbon), acid bichromate solution. Exterior vessel (zinc), solution of chloride of ammonium (sal-ammoniac).

2. Poggendorff element.

Interior vessel (carbon), acid bichromate solution. Exterior vessel, acidulated water.

The de Tromelin battery is superior to that of Poggendorff.

1. It emits no odour; the zincs are consumed regularly; there is no effervesence.

2. The depolarising fluid becomes exhausted in two hours; the capacity of the interior vessel being about 35 centilitres.

3. It would be necessary to increase threefold (in quantity) the number of couples in order to obtain a result equal to that of the Bunsen battery, which lasts during four hours.

4. The same battery mounted with fluids No. 2 gave inferior results: the zinc is consumed less regularly, there is a little effervescence. The substitution of a saturated solution of sal-ammoniac for the acidulated water is therefore advantageous.

5. In order to replace the Bunsen battery by that with bichromate and sal-ammoniac solutions, it would be necessary, first, to increase the number of couples connected for quantity, or to augment the surface; and, secondly, to increase the relative capacity of the carbon compartment.

EXPENSE OF A LE GOURANT DE TROMELIN BATTERY OF 24 COUPLES, CONSTRUCTED TO WORK FOR 4 HOURS.

Sal-ammoniac 1 kilog.	2fr. 50c.
Zinc (including waste) 300 grammes	0fr. 30c.
Bichromate of Potash, 2 kil.	4fr. 80c.
Maintenance, mounting, &c.	1fr. 25c.
Total	8fr. 85c.

or, say, 22c. per hour per *bec*, an expense which is far too great. The advantage of dispensing with nitric acid is compensated by the necessity of increasing threefold the number or the surface of the couples.

ROTARY BATTERY.

A battery of 12 circular zinc-carbon couples, 14 centimetres in diameter, immersed to a depth of about 2 centim. gave only insignificant results when the fluid in which they were immersed was water or a solution of sal-ammoniac.

With acid bichromate solution, the results were remarkable. The zincs were amalgamated, and the velocity of rotation was 80 revolutions per minute.

Composition of the fluid:—

Water	6 kilog.
Sulphuric acid	1 kilog. 200 gr.
Bichromate of potash	0 kilog. 500 gr.

At starting, the battery lit up tolerably effectively 2 incandescence lamps with carbons 2 millimetres in diameter; afterwards, more effectively, a single lamp. The experiment lasted during 45 minutes; at the end of this time the fluid was exhausted.

It would be necessary to use 8 couples in order to maintain a lamp giving a light equivalent to about 4 *becs*.

In order that the couples should last during 4 hours, the capacity of each trough should be 3 litres. The total expense in 4 hours would be:—

Sulphuric acid, 2 kilog. 800 gr.	0fr. 85c.
Bichromate 1 „ 700 „	4fr. 05c.
Zinc (including waste) 300 „	0fr. 30c.
Mercury 50 „	0fr. 30c.
Mounting and unmounting	0fr. 20c.
Total	5fr. 70c.

By doubling the surface of the carbon electrode, a light of about 8 *becs* would be obtained. The expense per hour and per *bec* would be about 18c.

Thus the disc battery, more convenient than any other when it is properly worked, must also be rejected on account of its high price and considerable expense in working.

We will mention only with a view of recording them some experiments made by amateurs with telegraph batteries. More than 200 large-size Leclanché couples, or more than 300 Calland couples, properly connected up, would certainly be required in order to obtain a small light.

The result of these investigations is therefore an absolute condemnation of the voltaic battery from the point of view of the production of the electric light, whenever an illumination continued for many hours is required. G. L.

LIGHTNING CONDUCTORS.*

In *The Times* of the 17th and 22d of May last there were notices of great damage which was done to the church at Laughton-en-le-Morthen by lightning, although the building was supposed to be very efficiently protected by a lightning conductor. Mr. Newall, F.R.S., writing from Gateshead a week or two later, shows, however, from an examination of the structure, that the conductor was most inefficient. The following is the substance of his statement:—The spire is 175 feet high, and it had attached to it, a *thin* tube of corrugated copper, about seven-eighths of an inch in external, and five-eighths internal diameter. The copper was about 1-32nd of an inch thick, and weighed 1¼lb. per yard. It was made in *short* lengths, connected by screws and coupling pieces, but there was *no metallic contact* between the pieces, which were much *corroded.* This conductor was *fastened to the vane*, and was *not in contact* with the building, but kept *at a distance* of 2¼ inches from it by twenty-one *insulators.* The earth-contact was obtained by *bending* the tube into the ground to about *a foot* in depth, the soil being *dry, loose* rubbish; while the length of the earth end was *only 3 ft.*, with two short pieces of about a foot long, each *tied to the tube* by *thin* wires. It was placed in a corner formed by a double stone buttress, which came between the conductor and the lead-covered roof, *separating them* by a distance of 6½ feet.

In this statement we have italicised the chief points in which the conductor was inefficient, and we find almost every mistake made that could be made in its erection and composition. No wonder then that the church suffered! Let us see what really happened:—The lightning appears to have come down the conductor for a certain distance, but finding it bad, it passed through a buttress, knocking out about two cart-loads of stone, and then came down the cast iron pipes from the lead-covered roof, and so to earth.

We take this late instance as our text, and we purpose, in this and a following article, to explain the theory and practical application of the subject of lightning conductors, because it is a matter that, as we know from an extended experience, very few architects really understand; while it is also one that merits most careful study if we wish to preserve uninjured our best buildings. We need only request our readers to compare the scientific conclusions which we shall lay before them with the italicised portions of Mr. Newall's statement to enable them to understand why its lightning conductor failed to be of much value to Laughton-en-le Morthern Church.

Among the ancients, as may be imagined, no really scientific

* From the *Building World*.

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method of protection of buildings from lightning existed. The Thracians are said to have been in the habit of shooting arrows at a thunder-cloud to deprive it of its electricity. The Romans believed that tents covered with seals' skins would defy the lightning; while Columella relates that some persons considered that a house was completely protected from thunderbolts by surrounding it with white grape vines. "Thunderstones" were formerly regarded as efficient protectors, and it was even said to be sufficient, when a storm was commencing, to strike such a stone thrice against each of the walls of a building to render it quite secure from injury by lightning. In the fifteenth century a naked sword was placed above a building or the mast of a ship with the same idea; and we fear that even at the present day, among uneducated people, the same kind of absurd practices might be noticed, for we have ourselves observed in Wiltshire an old broomstick protruding from the top of a farmer's rick, in order, as we were gravely informed, to keep off the lightning!

It is not our purpose, nor does space permit of our entering into the modern history of lightning conductors, which originated with Franklin. At the present time all scientific persons are convinced of their utility; while for others it will be sufficient to cite two examples, and to answer two objections. There is in Carinthia a church on a hill, which was for ages so frequently struck by lightning, that at last Divine service had to be regularly given up during the summer months. In 1778 the building was reconstructed and furnished with a conductor, since which time not only has the number of lightning strokes been largely diminished, but those which have fallen upon it have passed harmlessly down the conductor. Again, of six churches in Devonshire with lofty bell-towers, which have been struck within the last twenty years, all have suffered most severely, except one which had a good conductor; while a second, with an imperfect conductor, was partially preserved from injury. In fact, when lightning falls upon even imperfect conductors, it never occasions so much damage as when there is no conductor at all.

Some persons object to lightning conductors on the ground that they attract the lightning, and are therefore more dangerous than useful. This is quite a mistake. Their action is purely passive, and they operate just in the same way as rain-pipes, viz., in carrying off the discharge which falls upon them. They no more attract lightning than water-shoots attract rain. Rather do they diminish the number of strokes, in addition to carrying off those which do fall, as is well seen in the above instance of the Carinthian church. Other opponents have argued that we know not the *maximum* effect which lightning may produce, and that therefore our conductors may be of too small dimensions for some extraordinary storms. But when an engineer, for instance, decides about the width of the arches of a bridge, or the vault of an aqueduct, or the section of a drain, what does he concern himself about? He keeps somewhat beyond the dimensions suggested by the greatest floods which have been observed, without troubling about cataclysms in geological periods; and surely greater precaution than this is not necessary from the constructor of lightning rods.

But, in order to understand how a good conductor should be applied to a building, let us examine carefully what happens in a thunderstorm. When a cloud, highly charged with electricity, is brought by the wind over any spot, it begins by separating the positive and negative electricity in the earth below it by a process of induction, and then attracting strongly towards itself that electricity which is opposite in character to that with which it is itself impregnated. If, for instance, the cloud is, as is most usual, positively electrified, the earth, trees, and buildings under it are all negatively electrified, and the two electricities will tend to unite in the form of a flash through the line of least resistance. This line will naturally, in most cases, pass through the highest points of buildings, trees, etc., and if the buildings were themselves good conductors, no harm would happen to them. Take an instance. The column called the Monument, in London, erected in 1677, although 200 feet high, has never been injured by lightning, and why? Because it is terminated by a metal basin with rays, representing flames, and this basin communicates, by iron bars, with the iron balustrades of the staircase which descends down to the ground. This pillar is, in fact, an unintentional but perfect lightning conductor. But ordinary buildings are a mixture of good and bad conductors, and consequently, while the metallic parts of them allow the lightning to pass quietly, as soon as ever the metal ceases and the lightning has to traverse stone or wood sad havoc is the result. Our object, then, must be to provide for the electricity a route which shall be a line of least resistance, and any deviation from this line will leave the conductor so far imperfect. Let us then inquire what are the conditions and the characteristics of a good conductor.

First of all, the rod itself should be of copper, this metal being a better conductor of electricity than any other; and it is desirable that it should expose as large a surface as possible.* This may be effected by forming the rod of either flat bands united longitudinally, as in Sir W. Snow Harris's excellent method for the masts of ships, where each band is 4 feet long, and varies from $1\frac{1}{2}$ inches to 5 inches in width, and from $\frac{1}{8}$ inch to $\frac{1}{16}$ inch in thickness; or copper pipes from one to two inches in diameter, the metal being $\frac{1}{8}$ inch thick, and united in lengths of 10 feet each by short intermediate pieces furnished with screws; or a copper rope of about an inch in diameter, the strands of which are formed of wire as thick as may be while preserving sufficient flexibility to enable it to be adapted to the general contour of a building. It is most important that this rod, from its summit down to the ground, should have no solution of continuity arising from bad joints or corrosion, or the lightning will infallibly find another road. Sir Edmund Beckett, speaking of the way in which such a rod should be erected on a church-spire, for instance, says very justly that as many as can be of the top courses of the masonry should be tied down by a metal rod through the finial, and a cropbar inside, with a nut at the bottom; and that this rod, ending in the vane, should be the first part of the conductor, which, as he observes, it is quite useless and absurd to try and insulate from the building by glass rings or staples, as if the lightning would be likely to leave a good conductor, or to care about a glass ring if wished to leave it! Besides which, it is not only useless, but positively detrimental, as we shall show, to try to separate the conductor from the building by carrying it, as in the quoted case of Laughton-en-le-Morthen Church, some inches or feet away from the tower or roof. The fact is that the more closely the rod is incorporated with the building the more efficient it is. Sir W. Snow Harris, our best authority on the subject, when he "conductored" the Houses of Parliament laid the copper band actually *in* the wall, under the plaster; and Faraday himself, when a conductor was applied to the lighthouse on Plymouth Breakwater, insisted upon having a deep spiral groove cut in the granite wall from top to bottom, following the course of the stairs, in which to insert the massive copper band. Architects, therefore, should understand that separation and insulation of a conductor are more than useless; and that the main points to be attended to are, that it be of sufficient thickness, that it descend in an unbroken line with no gaps or weak joints, and that it avoid angles as much as possible. Let it, in effect, afford to the lightning, as far as the outline of the building will allow, the path of a straight line, which is the shortest distance between two points. Above all, if architects use wire ropes for the sake of ornamental adaptation to the contour of the structure, let them see that all the separate lengths of which the strands are composed are formed of wires not merely twisted together longitudinally, but well soldered, so that *each strand* may be without break or corrosion.

So much for the rod itself. Take now its two ends. Glass, being a non-conductor, it was formerly thought that the top of the conductor should be a thick glass ball, so as to keep off the lightning. Christ Church, Doncaster, was thus "conductored;" but in 1836 the ball was shivered and immense damage done to the spire. In the last century the question became even one of political acrimony as to whether the rod should be terminated by a metal ball or a point! It is now universally allowed that the end of the conductor should rise some feet above the highest point of the building, terminating in a point, or several points, of copper; or, if it is preferred, the points may be tipped with platinum, which, while it is not so good a conductor, has the advantage of being not so readily fusible by a severe stroke of lightning. Two important results flow from the use of *pointed* rods: First, a stroke of electricity enters the conductor without the violent disruptive effect which occurs when the rod is blunt or terminated by a ball; and secondly, the use of pointed rods has the advantage of *tapping* the thunder-cloud on its way, and silently withdrawing from it some of its electricity, thus diminishing materially the chances of an actual stroke, just as trees carry off in this way much electricity from the clouds, either by this silent method, or by small discharges, whose effect is seen afterwards by the timber merchant when he comes to saw up his wood, and finds often in them cracks and fissures, or "cupshakes."

Most important likewise is the connection of the lightning rod with the earth which must be as perfect as possible. This connection was about as bad as it could be in the case quoted at the beginning of our paper. The rod should enter the earth as

* In our view, the sectional area of the conductor, or its conductivity, is alone of moment; the quantity of electricity accumulated under static induction being in any case negligible in comparison with that passing to earth as a current.—Ed. *E.*

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deeply as may be practicable, and especially if the soil be dry and loose. De la Rive recommends that it should be led into a well, if there is one near enough, where the water is permanent; and, if not, then into the moist rock, by means of a trench or pit filled with baker's braise, which is a good conducting substance. If the rod is made to diverge at its end into several directions so much the better, only it should be most carefully arranged that the foot-rods be not merely tied by wires to the main conductor, but form integral parts of it, well soldered, and with complete contact. If, again, the conductor is led into an underground tank or well care must be taken that such well is not enclosed by masonry and cement, or, as might be shown by many instances if space permitted, this will form a great obstacle to the free diffusion of the electricity, and much damage may be the result. Let the rod enter the water of a brook or drain, or the deep moist earth of a meadow, or the damp rock, but avoid leading it into a close cistern or the hollow of a hard rock, which will oppose resistance to its free course, and either render the conductor useless, or produce, as has in such cases happened, a sort of recoil upwards of the lightning, which has proved as destructive to the building as its downward stroke when no conductor was present.

In our next paper we shall have to point out what results from the important fact that, although a conductor of the kind which we have just described may be considered a perfect safeguard against lightning so far as regards a stroke which may fall upon the spire, or tower, or chimney, to which it is affixed, yet it is *by itself* utterly useless as a protector for the whole of a large building; and that if a church or a range of buildings is to be secure, architects must understand that it is by no means sufficient, as they too often do, to hang a wire rope down one side of the structure, and let the rest take its chance! Other things have to be considered; for it is not by any means the case that a thunder-cloud will always condescend to come quietly just over the top of your rod, and discharge itself, as it ought no doubt to do, straight down your conductor!

THEORY AND LAWS OF THE MICROPHONE.

Mr. Julian Ochorowicz, of Lemberg University, writes as follows to our contemporary *Nature*:—

Two hypotheses have been projected to explain the action of the microphone. One is molecular exclusively, and supposes that the molecules of certain conducting bodies contract and dilate under sonorous vibrations. Changes of *density* correspond with an increase or diminution of the resistance of the circuit. This hypothesis renders the phenomena analogous to those which selenium presents under the influence of light and radiant heat. The other explanation, partly mechanical and partly molecular, is the result of a discovery made some time since by M. du Moncel, according to whom the increase or diminution in resistance is due to changes of *pressure* at the points of electric contact. These changes of pressure are effected by the vibration of the air; hence the cause and the effect are similar.

As the result of numerous experiments, I shall endeavour to prove that, while one of these theories is altogether erroneous, the other is only superficially true.

1. If the piece of charcoal is fixed with wax without any presure, the microphone remains silent under the strongest sonorous impulses, which would be impossible were the movement molecular.

2. The microphone may be enclosed in a vacuous chamber without altering the result; in this case waves of air can have no effect upon the density of the charcoal.

3. It is impossible to construct a microphone from one solid piece of charcoal, presenting stable contact, such as would not interfere with molecular action, but which prevents the sonorous waves from affecting the currents which traverse the carbon.

These afford sufficient reasons for rejecting any simple molecular theory.

Now against the second theory.

1. Lateral pressure on a compact electric conductor excites no microphonic action.

2. Longitudinal pressure within certain limits on the charcoal does not injure the apparatus.

3. An apparatus can be made to yield microphonic effects where there is no alteration of pressure. Pressure, therefore, is no essential cause of microphonic sounds, though it may be an accidental one.

In all microphones where contact is made at one point only, the current is interrupted whenever this point of contact is broken; a musical sound is heard when the two points are in vibration. This microphone, like Reis's telephone, can only transmit musical sounds. I have obtained the best results from a steel point and a membrane of a stretched bladder. A strip of tin-foil is gummed to the membrane to insure electric contact. With a single small cell of bichromate of potash a song can be heard through a whole room.

To transmit articulate sound it is necessary that the number of points of contact, the difference in this number during action, and the resultant changes of resistance, should be greater. The interruption of the current is then only partial; it becomes "undulatory." To this description belong the principal microphone of Mr. Hughes, Edison's carbon telephone, the transmitting telephone of two graphite pencils of MM. Pollard and Garnier, Helleren, &c.

A convenient form of microphone, which transmits words, music, the noise of a watch, &c., has the membrane of india-rubber stretched tight by a thin strip of tin-foil which unites the carbon underneath with the screw. The vibrations of the membrane throw a greater or less number of points into contact; all the shades of expression in the voice may be transmitted, owing to the rapidity of these small changes. It is the changes in the points of contact which here play the chief part, and there is little doubt that here we have the quality as well as the intensity of a sound reproduced.

This explains many of the microphonic actions, but not all. Here is one case:—

If the microphone is formed of two cylindrical pieces of charcoal, the points of contact cannot be made to vary by pressure, supposing the cylindrical shape to be perfect. The action here is due to the distance the current has to traverse the bad conductor; for the membrane to which these charcoal points are attached approaches or recedes from them when vibrating. The liquid telephone transmitters of Bell, Gray, and Salet rest upon the same principle where a change of resistance in the circuit is due to the varying depth of liquid traversed by the current. This, equally with the theory of the points of contact, explains the microphone of M. Righi, where a metallic disc is plunged into a powder of lead and silver mixed.

The next class of instruments consists of those where the current is created, and varies under the influence of microphonic electrodes (by this I mean the opposite parts of a microphone, whether in direct or indirect contact). Such are microphonic batteries. Each battery can act as a microphone if one of its poles is movable. Two ends of iron wire dipped in ordinary water and brought together give signs of microphonic action. One pole is attached to the vibrating membrane, and dips at its extremity into the liquid, while the other pole remains there constantly. The current only passes when the movable pole is in the liquid. On singing into the tube the vibrations of the membrane cause the pole, which is also a microphonic electrode, to dip into the liquid, setting up chemical action as many times a second as there are vibrations in the note sung. If the pole touches the liquid constantly the current is constant, but varies in intensity for four reasons: the different number of points exposed to electrolytic action; the different number of points of electric contact; the different number of the points of resistance of the liquid; and the different number of the points of approach of one pole to the other; all these are due to the movement of one of the microphonic electrodes.

There is yet another class of microphones. In all the instruments hitherto constructed the direction of the current remains the same, but it is possible to make it change, thus introducing another difference in the manner of its action.

In all the possible forms of microphone the chief causes of the action are:—a mechanical movement of its parts, a change in the points of conductivity, a change of resistance; these three essentials result from one another. The expression "points of conductivity" includes not only the points of contact, but also the route taken by the current.

The next point of consideration is the so-called increase of sound by a microphone, but this is not the case. All sounds are weakened by the microphone, and are transmitted only when the source of sound is in direct contact with the microphone or its stand. The microphone is less an instrument for transmitting sound than for transforming mechanical movement into sound. The intensity of a sound is, therefore, directly proportional to the energy of the mechanical movement accompanying the sonorous waves, or as a necessary consequence to the changes of resistance in the microphone. The distinctness of articulate sounds, transmitted by the microphone, is in inverse proportion to their intensity; for a loud sound tends to interrupt completely the current, and thus to prevent the transmission of articulate sounds. This is the chief hindrance to increasing, at pleasnre, the loudness of the sound. The loudness of the sound is also dependent on the strength of the current.

Other experiments prove that the rapidity of movement of the parts of a microphone also affects very considerably the resultant

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sound, as well with a strong, as with a feeble current. Changes in resistance and in current strength are not sufficient, unless made rapidly, to excite microphonic action.

Great as is the invention of Mr. Hughes, the microphone reveals no new property of matter, neither does it show the direct effect of sonorous waves upon partially conducting bodies.

POST OFFICE TELEGRAPHS.

The annual report of the Postmaster-General for the financial year ended 31st March, 1879, has just been presented to Parliament, and shows a satisfactory rate of progress in most branches of post-office work. As regards the Telegraph Department, it is satisfactory to find that, notwithstanding the depression in trade, there is an increase in the number of messages over the preceding year, though only to the extent of 317,617. The total number of messages forwarded was 24,459,613, and of delivered 22,792,000. Nearly 286 millions of words of news were delivered in the course of the year to newspapers, clubs, &c. The total number of telegraph offices open on the 1st of March was 3,853, in addition to 1,401 railway stations. Several improvements have been introduced in the apparatus, and the adoption of the quadruplex apparatus, by means of which one wire is made capable of simultaneously conveying four streams of messages—two in each direction—has added another to the fast speed instruments in use by the department.

The process of superseding overhouse by underground process in London and other large towns is being continued, and the private wire business—more affected than any other by the state of trade—shows a satisfactory increase. Most of the claims by the railway companies have been disposed of or are in a fair way of settlement, and Lord John Manners hopes to shortly close the telegraph capital account, the payments on which amounted on the 31st of March, 1879, to £10,120,075.

The true financial results of the telegraph business of the year will be exhibited in the profit and loss accounts to be presented shortly to Parliament; but the gross earnings of the telegraph service in the year ended the 31st of March, 1879, amounted to £1,346,892, as compared with £1,338,542, the amount of the gross earnings in the previous financial year, the increase being £13,350. The expenditure for the same period was £1,089,000, against £1,164,000 in the preceding year, being a decrease of £85,000. The decrease, however, was chiefly due to fluctuation of some of the charges, and not altogether to actual decrease of expenditure.

LITERATURE.

The Student's Text-Book of Electricity. By H. M. Noad, F.R.S. New Edition, carefully revised, with an Introduction and Additional Chapters by W. H. Preece, M.I.C.E. [Crosby Lockwood and Co.]

"This new edition of 'The Student's Text-Book of Electricity' was projected by Dr. Noad shortly before his lamented death. It was taken in hand and partially edited before it fell to my lot to complete the work. Very little of the old matter has been excised, but much new matter has been introduced. The chief difficulty met with has been not to know what to insert but what to exclude. The original plan has been carefully adhered to, so as to make it a reflex of the existing state of electrical science adapted for students."—*Vide* Editor's Introduction.

These few sentences will help us to apportion the credit to be given to or withheld from the producers of this work. The result of Dr. Noad's conception of what a text-book should be is hardly in accordance with the spirit of the age, and no amount of editing will render it *the* work for the student. We have no work on electricity similar to Miller's on chemistry, and yet there seems to be no reason why we should not—perhaps the promised work of Clerk-Maxwell will answer all purposes. It seems to us that a text-book of the pretensions of the one before us should never leave the *why* and the *wherefore* of the student unanswered. An example of failure in this respect is to be found in par. 6, pp. 7, 8, 9, 10. The author gives Coulomb's law of attraction and repulsion, aiding the student to the why of the law by citing *one* experiment. He then proceeds to give a number of results obtained by Snow Harris—how these results were obtained is not stated—hence the student cannot test their reliability. We hold that some description should always be given as to the method pursued in obtaining such results. In the next chapter on induction the author describes certain experiments and proceeds p. 12. "From these we learn," &c. This is more as it should be, although we think the whole chapter on induction should have been re-written. On p. 28 is another illustration of how the student is left in ignorance. The author, speaking of Varley's use of ebonite instead of glass in a plate electrical machine at the Exhibition in 1851, goes on to say, "A large induction ring was used with the machine on the plan recommended by Dr. Winter of Vienna." The peculiarity of this ring or how it was used is left to the student to infer, the inference being, we venture to think, of surpassing difficulty. We feel bound to mention our disagreement with the author's plan, and to point out what we think blemishes, and without entering further into this part of the subject will turn to a more congenial task.

For those younger students who have not seen previous editions of this work, we shall briefly refer to its contents. Commencing with a chapter of frictional electricity, Dr. Noad discusses in it various fundamental phenomena, conduction and insulation, attraction and repulsion, &c. With regard to the latter, we have almost come to the conclusion that all electrical phenomena generally looked upon as due to repulsion are really phenomena of attraction. We believe Mr. Sprague in his work deals somewhat with this question, without, however, expressing a decided opinion. It may be since that work was issued he has found reason to alter or decide the question. We should be glad to find more of our workers paying attention to this; although it may have little or no influence upon calculations, it is important that when doubts are felt they should be determined. The question of induction which is treated in the next chapter is a very large one, but, since Dr. Noad wrote, has received considerable elucidation. In connection with the succeeding pages we would advise the reading of F. C. Webb's little work on "Electrical Accumulation." Unfortunately the work is now out of print, but it may, perhaps, be seen in libraries, and occasionally at some old book-stall. A portion of the second part of the work, as well as the first, was published in the columns of *The Electrician* (Old Series). Comparison between the two writers on such subjects as "Communication with Earth," "The Earth a Great Natural Reservoir," *vide* p. 2829; "Charge by Cascade," p. 48; "Accumulation, &c.," p. 56-7-8 &c., would be very instructive. There is a good deal of information in Dr. Noad's work in these chapters, and the method adopted is shown at its best. Some of the paragraphs are admirably concise and simple, giving everything, that is required and amply illustrated. Nearly fifty pages are now devoted to Atmospheric Electricity, and almost all the best known writers on this subject have been laid under contribution to supply information. The following paragraph gives the "Positions of Safety During a Thunderstorm:"—If out of doors trees should be avoided, and if, from the rapidity with which the explosion follows the flash, it should be evident the electric clouds are near at hand, a recumbent position on the ground is the most secure. It is seldom dangerous to take shelter under sheds, carts, low buildings, or the arch of a bridge; the distance of twenty or thirty feet from all tall trees or houses is rather an eligible situation, for should a discharge take place these elevated bodies are most likely to receive it, and less prominent bodies in the neighbourhood are likely to escape. It is right to avoid *water;* for it is a good conductor, and the height of a human being near the stream is not unlikely to determine the direction of a discharge. Within doors we are tolerably safe in the middle of a carpeted room, or when standing on a double hearthrug. The chimney should be avoided, as, when a building is struck with lightning the charge is generally determined towards it, in consequence of the good conducting power of the carbon or soot; upon the same principle gilt mouldings, bell wires, &c., are in danger of being struck. In bed we are tolerably safe, blankets and feathers being bad conductors, and we are consequently to a certain degree insulated. It is injudicious to take refuge in a cellar, for it has sometimes happened that buildings that have been struck by lightning have sustained the greatest injury in the basement story.

(TO BE CONTINUED).

ANSWER TO CORRESPONDENT.

A. Westwood and Co.—A translation into English of the work by Mr. H. Fontaine on "Electric Lighting," and the recent works of Dr. Paget Higgs, on "The Electric Light" and "Electric Transmission of Power," containing much information on dynamo-machines, are published by Messrs. Spon, Charing-cross.

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CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

The 16th ordinary general meeting of the shareholders of the above Company was held on Wednesday, August 20, at the offices, Old Broad-street, Mr. T. Hughes, Q.C., the Chairman, presiding.

Mr. James Scott, the secretary, read the notice convening the meeting, and the report of the Directors was taken as read. It stated that for the half year ending the 30th June last the gross receipts, including the balance brought from last account, amounted to £22,360, and the gross expenditure to £9,086, leaving a sum of £13,274 to the credit of revenue account. The above amount of £9,086 included, however, the sum of £5,756, the cost of the repair of the Cienfuegos-Santiago section of the original cable, the ordinary expenses being £3,330. This repair was completed in March last, but the Directors regret to report that the cable again broke down in the end of June, off Turquino. The Directors had considered it advisable to place £4,100 to the credit of the reserve fund, increasing that fund to £23,011. The balance of revenue, after providing for the dividend on the preference shares, would admit of a dividend on the ordinary shares at the rate of 6 per cent. per annum, leaving £1,374 to be carried forward.

The Chairman, in moving the adoption of the report, said the principal point to which the attention of the shareholders had been directed, as was the case with the Directors, was the amount of business done. The reasonable expectation of telegraph companies was that the business would increase to something like 10 per cent. a year, but last year their business was precisely the same, within £200 of what it was in the corresponding period of 1878. The principal reason for this was the falling off in the local traffic, in consequence, as the shareholders were aware, of the opening of the Government lines. That falling off had amounted, during the past half year, to something like one-third, as compared with last half year. The want of business was also owing to the condition of their allies and neighbours, the West India and Panama Company, who had unfortunately had a great many breakages in their cables. Another reason which had acted more or less against them was the very inadequate sugar crop in the past spring, and to these causes might of course be added the general depression of trade. In fact he thought that the shareholders might all rather be congratulated on the fact that the traffic had not fallen off more than it had. Looking forward to the future, he was happy to say that it was the opinion of their very excellent clerk, who had been in that country for some years, that the Company would in all probability recover a very considerable portion of the local traffic before long, because the Government lines were not worked with the same intelligence and punctuality as theirs. There were contingencies which might largely increase their business, and which he trusted might not be entirely unfulfilled very long. Of course, if M. de Lesseps's plan of carrying the canal through the American isthmus should be carried out, as there was reasonable hope that it might be, a very great increase of traffic would come on the West India lines and the Company's; and in the same way, when the Brazilian lines were connected with theirs, a large extension of traffic might be expected in that direction. On the other hand, it was clear to all of them now that the seas in which their cables were laid were unfavourable to their "life," and that brought them to the very important question of repairs. The shareholders would have noticed that their gutta-percha cable, which was so recently repaired—satisfactorily repaired, but at very considerable cost—had again broken down, and almost in the same place as on the previous occasion. Their engineer out there, in the course of the repairs ascertained that there was a very sudden fall in the soundings, which led him to the conclusion that there was a very sharp reef there, going down almost perpendicularly for a very considerable distance, and they thought it was almost certain that their cable at that point hung upon some sharp reef of rock. They had, therefore, arranged, in the repairs which they must execute in the course of the next few months, that the cable should be carried out beyond this reef, and to deeper water; and that accomplished, they believed that this dangerous point, off Turquino, would in future be practically harmless, so far as their cables were concerned. They proposed to send out sufficient cable for this purpose—about eight or ten knots of cable—and he was sure it would be worth their while to incur this expense. The question of repairs also brought him to the point which had always been insisted upon by the Directors, and as to which their views had been very cordially responded to by the shareholders—he referred to the question of the reserve fund. In looking carefully through the past history of the Company, they found that the average expenditure on repairs had amounted to something like £4,900 a year. That, however, included the enormous sum which they had to pay for their first repair, when they were compelled to employ the Construction Company, and send out a large vessel from this country. That work cost them £20,000, but it would never occur again. They now had a competent man on the spot, who performed the repairs very satisfactorily, and infinitely cheaper. At the same time, they thought they ought to look forward to an expenditure of between £4,000 and £5,000 in the repairs of cables in those seas, and that led them to the consideration of the reserve fund, and whether they were making sufficient provision for that very necessary portion of the Company's assets. At the present time it amounted to a very respectable figure—£23,000—but the opinion of the Board was that they would not be perfectly satisfied or in a thoroughly sound position until they had accumulated sufficient reserve fund to meet somewhere about the yearly expenditure which they must look forward to for repairs. Therefore they thought they would not be wise in increasing the dividends largely, at any rate, until the reserve fund had been very considerably increased.

Mr. J. De Mancha, a Director, having seconded the motion, a short discussion ensued, and in reply,

The Chairman said they were now on very friendly terms with the West India and Panama Company. They formerly had a large claim against that company in connection with the joint ownership of a repairing vessel, but the matter was submitted to arbitration, and they received from that company a sum in cash and £4,000 in their debentures, which they held still, and on which they received 6 per cent. The cable in stock was not anything like sufficient for the repairs referred to, and it was not deep-sea cable. They had, therefore, ordered 20 knots of cable, of which 8 or 9 knots would be used in these repairs. They were not asked to take part, nor did they, in the recent deputation, the main object of which was to obtain some assistance from the Government in maintaining the present lines of the West India and Panama Company, which certainly required additional subventions. They heartily hoped that the application of their neighbour would be successful. There had been no break in the Cuba Company's communication; their cables were duplicated. The Spanish Government acknowledged that they owed the Company £1,000, and there was no doubt that it would be paid sooner or later. It was quite clear, although people could send their messages the other way, that the greater portion of their business would not be so sent, because it was business from the United States. That was not likely to be sent round by Madeira and Europe; and there was no doubt that theirs was, and would remain, the cheapest route.

The report was then unanimously adopted, and Mr. Horatio J. Perry, the retiring Director, was re-elected, as was also the retiring auditor, Mr. James Cowan.

On the motion of Mr. Griffiths, seconded by Mr. John Newton, a vote of thanks to the Chairman and Directors terminated the proceedings.

RECENT PATENTS.

4690. Electric Regulators, Lamps or Candles, *J. H. Johnson.—Dated 19th November, 1878.—(A communication.)—(Not proceeded with.)* 2*d.*

The lamp or candle is placed under a transparent dome in the form of an inverted test glass, in such a position that the stationary luminous point is situate at at least two-thirds of the total height from the lower extremity of the dome, or when not stationary it is arranged so as to be half-way up the dome when the candle is completely consumed.

4705. Distributing, Regulating, and Applying Electric Currents for Lighting, &c., *F. J. Cheesbrough.—Dated 19th November, 1878.—(A communication.)* 1*s.*

A single conductor with two or more lamps in the circuit has a shunt around each lamp containing a switch. The shunt contains an adjustable resistance. A measuring apparatus is employed to register the amount of current consumed by the lamp.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Aug. 20.		Business Done Week Ending Aug. 20. Highest.	Lowest.
Anglo-American	53½,	¾	53⅞	53
Do. "B"	82¼,	¾	82⅛	81¾
Do. "A"	26½,	7	27⅛	26¾
Brazilian	6⅞,	7	7 1-16	6⅞
Cuba	7¾,	8¼	8⅛	—
Do. Ten per Cent. Preference	15¾,	16¼	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	11⅝	11¼
Direct United States	10¼,	⅝	10⅜	10¼
Eastern	7¾,	⅞	7⅞	7⅝
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do	101,	103	102⅜	102
Do. Six per Cent. Preference	11¾,	12	12⅛	12
Eastern Extension	7⅝,	⅞	7 15-16	⅞
Do. Six per Cent. Deb.	105,	108	—	—
German Union	7½,	8	7 13-16	—
Globe Telegraph and Trust ... x d.	4⅞,	5	5	4 15-16
Do. Six per Cent. Preference ... x d.	11,	⅛	11⅛	11
Great Northern	8⅜,	⅝	8 9-16	8⅜
Indo-European	21,	22	—	—
Mediterranean Extension	2¾,	3¼	3⅛	3
Do. Eight per Cent. Preference	9¼,	¾	9½	—
Reuter's	9,	10	—	—
Submarine ... x d.	220,	225	—	—
West India and Panama	1¼,	⅝	1⅝	—
Do. Six per Cent. Preference	7⅜,	⅞	7¾	7⅝
Western and Brazilian	3,	¼	3⅛	3
West. Union Seven per Ct. 1st Mt.	118,	122	—	—
Do. Six per Cent. Sterling	107,	109	—	—

TRAFFIC RECEIPTS FOR JULY, 1879.

Companies.	July 1879.	July 1878.	Incrse.	Decrse
Cuba Submarine Company	2,800	2,608	192	—
Direct Spanish Telegraph Company	913	812	101	—
Direct United States Telegraph Company	16,440	—	—	—
Eastern Extension Telegraph Company	23,411	24,927	—	1,516
Great Northern Telegraph Company	20,421	—	—	—
West Coast of America Telegraph Company.	725	—	—	—

INSULATED COPPER WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handled Cord, Silk Cord for Electric Bells, &c.—J. and W. RICKARD, Insulated Wire Manufacturers, Derby.

ELECTRICAL, SCIENTIFIC, and PHOTOGRAPHIC APPARATUS for AMATEURS and the TRADE.—Electric Bells, Indicators, and Automatic Switches. Microphones from 1s. 6d. Induction Coils, Lamps and Batteries, Magnets, Wires, Carbons, Terminals, &c. Illustrated Catalogue one stamp. Most Sensitive Dry Plates, Paper, and Chemicals. Photographic List free. Repairs and alterations to instruments.—DALE and CRAMPTON, Manufacturing Electricians, 4, Little Britain, London, E.C.

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NOTES.

Lecture of Prof. Ayrton.—More than three thousand working men attended to hear this admirable lecture which we give in another column.

Appointment.—Major C. E. Webber, R.E. (late of the Postal Telegraph Department), who accompanied Sir Garnet Wolseley to Natal on special service, has been appointed Assistant-Adjutant and Quartermaster-General with General Newdigate's division.

Electricity as a Motive Power.—This subject, which is attracting a good deal of attention at present, has been treated by Dr. Paget Higgs in a small work—which we hope to notice at length in another issue—published by Messrs. Spon of Charing-cross.

Smart Work.—An enterprising tobacco manufacturer of the north recently did a smart thing. He had the electric light put up in his factory, had it well puffed in the daily papers as likely to supersede gas, invited people to see it—and bought gas shares largely at a low price! The electric light was not a success, but the gas shares were.

Death of an Actor by Lightning.—A painful scene recently occurred at the Altorf Theatre. As "Lucia" was being performed, a violent thunderstorm burst over the house. The tenor was singing the air in the malediction scene, when Edgardo fell forward, struck down by lightning. He was immediately raised from the ground, and though then alive, was found to be paralysed in every limb. The performance, of course, was brought to an abrupt termination.

Electro-Deposition of Brass.—The affinity between copper and cyanogen appears to vary directly, and that between zinc and cyanogen to vary inversely as the temperature. Advantage is taken of this fact in depositing brass from the solution of the cyanides of copper and zinc with cyanide of potassium and carbonate of ammonia which is known as Moriss and Johnson's patent solution. When the deposit is too light in colour, the temperature of the liquid is raised; when it is too coppery the temperature is lowered. The proportion of copper deposited is also augmented by increasing the proportion of cyanide of potassium; whilst, if the carbonate of ammonia preponderates, the deposit is rich in zinc. By the application of these facts, a brass of any required composition may be deposited.

Telegraphic Communication with South America.—A deputation of West India proprietors and merchants, with the chairman and directors of the West India and Panama Telegraph Company, have had an interview with Sir Michael Hicks-Beach at the Colonial Office, to ask Her Majesty's Government to grant the telegraph company a subvention to enable it to repair the cables to the West Indies and South America, which at present are broken; communication with several British colonies being thus prevented. The deputation stated that during the last six weeks two of the telegraph wires had broken, whereby communication between the two countries was interrupted. Sir Michael Hicks-Beach, in reply, said that whilst the Government admitted the necessity of granting subventions in some cases to private companies, they were of opinion that this should only be done where purely Imperial needs had to be provided for, and then only when such needs could not equally well be supplied in any other way. He should see how far the circumstances of the present case came within that line of policy, and communicate with the deputation hereafter.

The British Association.—The following papers of an electrical nature have been read at the late meeting of the British Association at Sheffield. We hope to be able to give the papers in due course, with the sanction of the authors and the permission of the Association. Mr. J. E. H. Gordon read two papers—(i.) On some new instruments recently constructed for the continuation of researches on specific inductive capacity. (ii.) On secular changes in the specific inductive capacity of glass. Prof. S. P. Thompson (i)., Retardation of phase of vibrations transmitted by the telephone. (ii.) The action of magnets on liquid jets. Dr. M. Grabham, Report of the Committee on Atmospheric Electricity. Dr. O. J. Lodge (i.) On a hypothesis concerning the ether in connection with Maxwell's theory of Electricity. (ii.) On an Electrometer Key. W. Ladd, Improvements in dynamo-electric machines. W. H. Preece, On lightning protectors for telegraphic apparatus. J. N. Shoolbred, On recent advances in electric lighting. A. J. C. Allen, On some problems in the conduction of electricity. W. H. L. Russell, On the repulsion of wires influenced by electric currents. Conrad W. Cooke, On a galvanometer for demonstrating the internal current in a voltaic cell. W. Chandler Roberts, To exhibit some experiments with Hughes' voltaic induction balance. E. A. Cowper, On the writing telegraph.

New Rules of the Road at Sea.—These rules, which come into operation on September 1, 1880, apply not only to British ships, but also to the royal and commercial navies of Austria-Hungary, Belgium, Chili, Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, and the United States, whether within British jurisdiction or not. The rules contain an entirely new article, viz., Art. 5, designed to meet the case of ships not under command, such as vessels laying telegraph cables, vessels to which accidents have happened. The following is the new rule:—"Art. 5.—A ship, whether a steamship or a sailing ship, when employed either in laying or in picking up a telegraph cable, or which from any accident is not under command, shall at night carry in the same position as the white light which steamships are required to carry, and, if a steamship, in place of that light, three red lights in globular lanterns, each not less than 10in. in diameter, in a vertical line one over the other, not less than 3ft. apart; and shall by day carry, in a vertical line one over the other, not less than 3ft. apart, in front of but not lower than her foremast head, three black balls or shapes, each 2ft. in diameter. These shapes and lights are to be taken by approaching ships as signals that the ship using them is not under command, and cannot, therefore, get out of the way. The above ships, when not making any way through the water, shall not carry the side lights, but when making way shall carry them."

Coating Iron with Iridescent Copper.—A writer in the *Mining Journal* thinks the invention of Dr. Weil, of

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Paris, for coating iron and steel with copper or nickel in such a manner that the surfaces shall be iridescent, opens a large field for the employment of metal for decorative purposes. He has found that the best mode of preparing the metalising bath and the best proportions of ingredients are indicated in the following directions: First, 35 parts of crystallised sulphate, or an equivalent amount of any other salt of copper, are precipitated as hydrated oxide by means of caustic soda or some other suitable alkaline base; this oxide of copper is to be added to a solution of 150 parts of Rochelle salt, and dissolved in 1,000 parts of water; to this 60 parts of best caustic soda, containing about 70 per cent. NaO, is to be added, when a clear solution of copper will be formed. Other alkaline tartrates may be substituted for the Rochelle salt above mentioned, or even tartaric acid may be employed, but, in the case of tartaric acid or acid tartrates, a small additional quantity of caustic alkali must be added, sufficient to saturate the tartaric acid or acid tartrate. Oxide of copper may also be employed, precipitated by means of hypochlorite, but in all cases the proportions between the copper and the tartaric acid should be maintained as above, and it is advantageous not to increase to any notable extent the proportion of the caustic soda. The object to be coppered is to be cleaned with a scratch brush in an alkalino-organic bath, attached as a cathode, immersed in the coppering bath, and treated with the usual precautions, when it will become rapidly coated with an adherent film of metallic copper. As the bath gradually loses its copper, oxide of copper as above prepared should be added to maintain it in a condition of activity, but the quantity of copper introduced should not ordinarily exceed that above prescribed as compared with the quantity of tartaric acid the bath may contain. If the quantity of copper notably exceeds this proportion certain metallic irisations are produced on the surface of the object. These effects may be employed for ornamental and artistic purposes. According to the time of the immersion, the strength of the current, and the proportion of copper to the tartaric acid, these iridescences may be produced of different shades and tints, which may be varied or intermingled by shielding certain parts of the object by an impermeable coating of paraffin or varnish, while the iridescent effect is being produced on the parts left exposed. All colours, from that of brass to bronze, scarlet, blue, and green, may be thus produced at will. If it be desired to deposit nickel, the only modification of the above process requisite is the substitution of precipitated oxide of nickel for the oxide of copper, produced by precipitation as above mentioned. In the above process it will be observed that the introduction of sulphuric acid into the bath is avoided, at least except in such insignificant quantities as may still adhere to the precipitated metallic oxides.

Atmospheric Phenomenon.—The Geneva correspondent of *The Times* writes, under date August 22:—"On the evening of August 5, six persons who were standing in the gallery of a *châlet* in the Jura, above St. Cergues, witnessed an atmospheric phenomenon equally rare and curious. The aspect of the sky was dark and stormy. The air was thick with clouds, out of which darted at intervals bright flashes of lightning. At length one of these clouds, seeming to break loose from the mountains between Nyon and the Dole, advanced in the direction of a storm which had meanwhile broken out over Morges. The sun was hidden and the country covered with thick darkness. At this moment the pine forest round St. Cergues was suddenly illuminated and shone with a light bearing a striking resemblance to the phosphorescence of the sea as seen in the tropics. The light disappeared with every clap of thunder, but only to re-appear with increased intensity until the subsidence of the tempest. M. Raoul Pictet, the eminent chemist, who was one of the witnesses of the phenomenon, thus explains it in the last number of the *Archives des Sciences Physiques et Naturelles*:—'Before the appearance of this fire of St. Elmo, which covered the whole of the forest, it had rained several minutes during the first part of the storm. The rain had converted the trees into conductors of electricity. Then, when the cloud, strongly charged with the electric fluid, passed over this multitude of points, the discharges were sufficiently vivid to give rise to the luminous appearance. The effect was produced by the action of the electricity of the atmosphere on the electricity of the earth, an effect which, on the occasion in question, was considerably increased by the height of the locality, the proximity of a storm-cloud, and the action of the rain, which turned all the trees of the forest into conductors.'"

The Action of Light on the Voltaic Battery.—The question of the effect of light in modifying the electromotive force of certain forms of battery has been carefully studied by M. Edmond Bequerel. Some further researches in this direction, carried out by M. H. Pellat, at the laboratory of the Sorbonne, are, however, of considerable interest. This physicist constructed two Daniell couples, of high resistance, formed of two concentric glass vessels containing respectively the sulphate of copper and sulphate of zinc solutions, and communicating only through the minute space intervening between the neck of the interior vessel and its glass stopper. These two couples, perfectly transparent, were kept during five months. The zinc was not affected; but the copper became coated with a greenish deposit. In spite of this alteration, the elements were found to have maintained their initial e.m.f., which in one case was 1·15 volt and in the other 1·11 volt. This at least was the result of measurements made when the couples were in darkness; when they were exposed to the rays of the sun the e.m.f. was *diminished* by a quantity which reached one-fortieth of the total value, or ·029 volt. The effect of the light was very rapid, and ceased immediately the rays were intercepted by means of a screen. M. Pellat is confident that the effect is not due to an elevation of temperature; the immersion of the couples in fluid at 50° C. not producing any very sensible effect, whilst a red glass, allowing the passage of one half of the solar heat rays, produced the effect of an opaque screen. On the other hand, a glass trough containing a light blue solution which allowed of the passage of only one-seventh of the heat rays, was found to transmit one-fifth of those rays which were efficacious in producing the diminution of the electromotive force. It appears therefore that the effect is due to the more refrangible rays. When the copper element of the Daniell is quite bright, no effect is observable; it is necessary that the copper surface should have undergone some chemical change. By concentrating, with a lens, the solar rays on different portions of the couple, M. Pellat ascertained that the surface of contact of the tarnished copper with the sulphate of copper solution is alone sensitive to light. The effect of the luminous rays is to render the copper *less positive*. A sensitive Daniell couple may be constructed with a copper wire oxidised in the flame of a Bunsen burner; but in this case the effect of light is to render the copper *more positive*.

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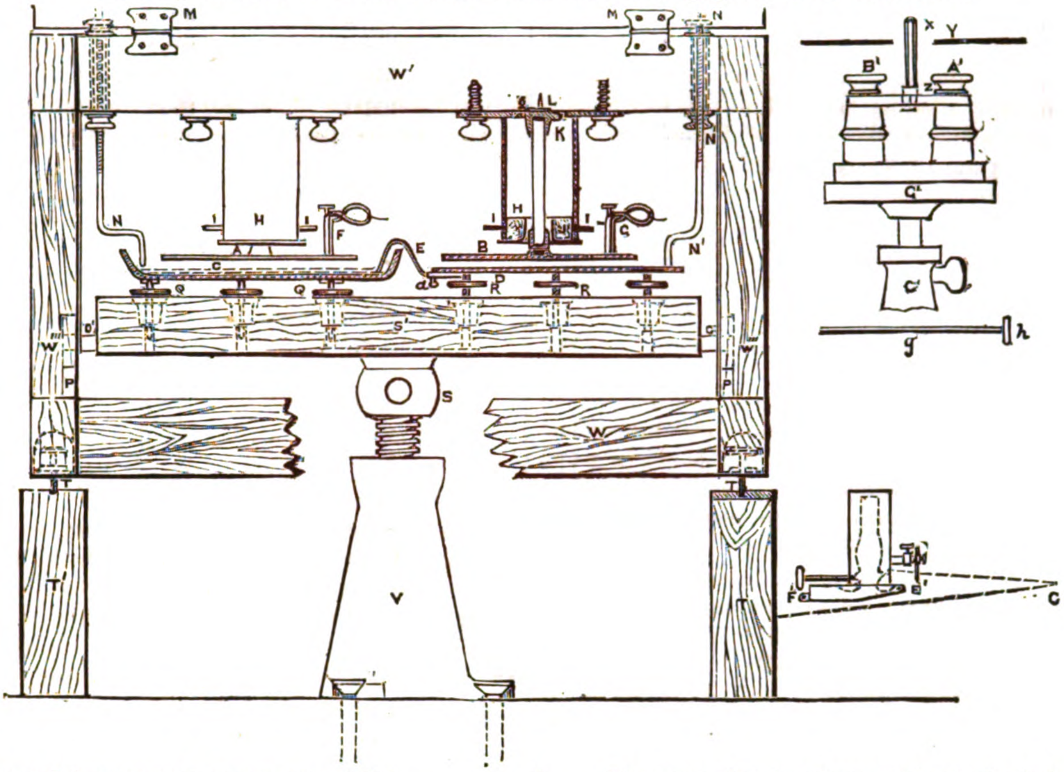
CONTACT THEORY OF VOLTAIC ACTION.—Parts I and II.

By W. E. Ayrton and John Perry, Professors in the Imperial College of Engineering, Tokio, Japan.

Drawing referred to in the matter under this heading given in our last issue.



Part I (continued from page 161.)

Table VI.—12th March, 1876. Plates 10·9 mm. apart.

Zinc and copper metallically connected. Zinc positive to copper.

Zero.	Reading.	Deflection.
1097·1	1133·1	36·0
85·5	1048·0	37·5
77·1	1112·0	34·9
80·0	1040·6	39·4
82·1	1119·1	37·0
86·8	1047·0	39·8
83·0	1114·4	31·4
86·3	1046·0	40·3
91·2	1123·0	31·8
90·0	1047·1	42·9
	Mean.....................	37·1

Zinc and copper connected by an acid solution of zinc sulphate at 10°C. Zinc negative to the copper.

1034·8	1026·1	8·7
34·1	41·8	7·7
36·9	30·1	6·8
37·1	49·1	12·0
39·7	31·1	8·6
40·0	51·5	11·5
45·0	35·1	9·9
43·0	55·1	12·1
43·0	35·0	8·0
42·3	52·1	9·8
	Mean.....................	9·5

Zinc and copper connected by distilled water at 10°C. Zinc negative to copper.

1040	1033·1	6·9
40	49·0	9·0
39·9	32·1	7·8
39·8	47·2	7·4
39·3	32·1	7·2
39·2	50·0	10·8
40·8	32·9	7·9
40·2	50·1	9·9
40·0	31·2	8·8
39·8	51·0	11·2
42·1	32·3	10·1
42·0	52·1	10·1
Mean	....	8·9
Mean of first eight obs	**...............**	**8·4**
Mean of last eight obs.	**...............**	**9·5**

The same after two hours without zinc being cleaned.

1037·0	1027·0	10·0
37·0	48·1	11·1
37·0	25·2	11·8
36·9	47·6	10·7
35·8	25·0	10·8
35·0	46·4	11·4
	Mean.....................	11·0

Zinc and copper connected by distilled water at 45°C. cooling during experiment to 20°C. Zinc negative to copper.

1037·2	1054·0	16·8
37·1	21·5	15·6
37·1	51·2	14·1
37·1	22·8	14·3
37·2	49·2	12·0
...	...	...
37·0	54·0	17·0
36·8	20·2	16·6
35·2	51·0	15·8
	Mean.....................	15·3

In the experiments of Table VI. the liquids were contained in small flat vessels which were placed below the metal plates near the middle of the table, strips of copper and zinc dipping into the vessel from the binding screws; these strips may have been of slightly different material from the plates, that is, we are not quite certain that they were cut from the same sheets. In all subsequent experiments, the strips of metal in contact with the liquids were cut from the plates themselves.

Table VII.—13th March, 1876. Plates 10 mm. apart.

Zinc and copper plates connected by the acid solution of zinc sulphate of Table VI. at 17°C. Zinc negative to copper.

Zero.	Reading.	Deflection.
1068·0	1085·9	17·9
68·4	62·8	5·6
65·8	74·8	9·0
66·1	58·5	7·6
67·1	55·2	11·9
67·1	72·0	4·9
	Cleaned the zinc strip.	
63·0	50·0	13·0
61·5	70·0	8·5
61·1	48·5	12·6
62·0	71·0	9·0
63·3	53·0	10·3
64·8	72·6	7·8
	Mean.....................	9·8

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Zinc and copper plates connected by dilute sulphuric acid. Zinc negative to copper.

Zero.	Reading.	Deflection.
1069·5	1057·1	12·4
68·8	76·4	7·6
68·2	62·0	6·2
68·0	73·9	5·9
68·2	62·2	6·0
68·0	73·2	5·2
67·0	61·9	5·1
66·2	68·9	2·7
	Cleaned the zinc strip.	
61·3	51·0	10·3
62·1	70·1	8·0
63·0	55·0	8·0
63·4	68·0	4·6
63·0	56·0	7·0
62·2	67·3	5·1

The mean deflection for zinc and copper contact at 10°C. being 37·1.

It is to be observed that although there was a motion of the electrometer needle when the quadrants were insulated (shown by the great difference between every two successive readings), still the observations are sufficiently consistent, and when taken two by two they show that polarisation has the effect of decreasing the readings. Taking the means of every two successive readings we have in the zinc sulphate, 11·75, 8·3, 8·4, and again, after the zinc is cleaned, 10·75, 10·8, 9·0. In the acid this effect is even more marked, the deflections diminishing rapidly from 10·0 to 3·9, and again from 9·15 to 6·0. Thus we see that polarisation in the ordinary sense, so far from producing a difference of potentials between zinc and copper joined by a liquid, in reality tends to reduce the difference of potentials that already existed between them.

The electrometer now began to show the existence of two faults, imperfect contact between the electrodes and the quadrants, and a slight discharge from the needle to the quadrants. The instrument was, therefore, taken to pieces, and the first fault rectified by the addition of contact springs (in addition to the little weights previously employed) between the electrodes and quadrants, and the second by the needle and quadrants being cleaned.

In observations made during the last four months on the constancy of electromotive force of cells, we found that Latimer Clark's cell when tested by an electrometer (kept in a perfectly constant state) altered very little when its poles were kept insulated. The electromotive force of this cell is known to be 1·457 volts, and we have used it as a standard to determine the changes produced in readings by changes in the positions of the quadrants.

When we compared the electromotive force of contact of zinc and copper with the constant cell, it was found in every case to be 0·75 volt at the temperature of 17°C. The deflections in the last two tables might be reduced to volts if we knew the contact electromotive force of zinc and copper at 10°C.

Table VIII.—13th April, 1876. Plates 10 mm. apart.

Latimer Clark's Cell.

Zero.	Reading.	Deflection.
955·0	892·0	63·0
954·5	1018·5	64·0
954·5	891·8	62·7
953·1	1017·1	64·0

Mean........................... 63·4

Assumed to be 1·457 volts.

Direct reading is 355

Therefore *ratio* is $\frac{355}{63\cdot4}$ or 5·6

Zinc and copper connected by distilled water at 17°C. Zinc is negative to copper.

953	960·2	7·2
952	947·0	5·0
952	960·0	8·0
952	946·5	5·5
951·9	961·0	9·1
952	945·0	7·0
952	961·0	9·0
952·9	946·2	6·7
	An interval of 15 minutes.	
953	961·0	8·0
953	961·0	8·0
952·8	945·1	7·7

Mean............7·32 or 0·168 volt.

Zinc and copper metallically connected. Zinc positive to copper.

Zero.	Reading.	Deflection.
953·0	926·0	27·0
952·7	990·0	37·3
951·0	920·3	30·7
950·1	985·1	35·0
950·0	919·5	30·5
950·2	984·6	34·4
951·0	918·0	33·0
951·1	985·2	34·1

Mean............32·7 or 0·751 volt.

Zinc and copper connected by saturated pure zinc sulphate at 17°C. Zinc negative to copper.

952·0	961·5	9·5
951·9	944·2	7·7
951·8	960·0	8·2
951·9	943·1	8·8
952·0	960·0	8·0
952·1	944·6	7·5
	Interval of 10 minutes.	
953·1	960·0	6·9
953·2	945·0	8·2
953·1	961·2	8·1
953·3	945·2	8·1
953·7	961·0	7·3
953·9	945·2	8·7

Mean of first six............8·3 or 0·191 volt.

Mean of last six............7·9 or 0·182 volt.

Table IX.—14th April, 1876. Plates 10 mm. apart.

Zinc and very dilute zinc sulphate (17°C.) in contact. Zinc negative to liquid.

Zero.	Reading.	Deflection.
1066·0	1073·1	7·1
1065·3	1057·3	8·3
1065·1	1072·3	7·2
1065·1	1057·0	8·1

Mean............7·7 or 0·177 volt.

Copper and very dilute zinc sulphate (17°C.) in contact. Copper is positive to liquid.

1060·0	1060·9	0·9
1060·0	1058·8	1·2

Mean............1·35 or 0·024 volt.

Slightly impure copper sulphate (at 22°·3C.) and very dilute zinc sulphate (17°C.) in contact. Copper sulphate is positive.

1058·0	1055·8	2·2
1058·4	1061·7	3·3

Mean............2·75 or 0·066 volt.

Copper and slightly impure copper sulphate (27°·3C.) in contact. No perceptible deflection.

Dipped copper in the above copper sulphate and zinc in the zinc sulphate and connected directly with electrometer. Deflection 246 or 1·010 volts.

We were subsequently rather sorry so few observations were made for each contact on the 14th of April; as the solutions were impure it did not at the time seem to be specially important to make the experiments with greater accuracy.

The insulated plates A and B were now cut, as they had hitherto been rather near the sides of the porcelain vessels. It was not until the 21st April that we could get a sufficiently large supply of pure saturated solutions of zinc and copper sulphates. On Friday evening, 21st April, we made our largest and most consistent series of observations. At no time since it arrived in Japan had the electrometer been in such good working order, and, therefore, we shall take the results of this evening, when possible, in preference to any others.

[The large amount of trouble we experienced with our quadrant electrometer, necessitating our taking it to pieces some ten times during this investigation, arose from our requiring to have it in an extremely delicate state. For whereas electricians, we are informed, are usually contented to obtain some 150 divisions deflection with the reversal of a Clark's standard cell, our electrometer, as we used it, gave us as much as 800, possibly the largest deflection that has ever been obtained by the reversal of a Clark's cell attached directly to the terminals of a quadrant electrometer.]

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Table X.—21st April, 1876. Plates 10 mm. apart. Latimer Clark's Cell.

Zero.	Reading.	Deflection.
1079·0	1019·5	59·5
72·1	1131·5	59·4
73·1	1014·0	59·1
74·7	1135·0	60·3
79·1	1020·6	58·5
83·5	1143·7	60·2
85·8	1026·5	59·3
86·0	1145·5	59·5
87·6	1028·3	59·3
86·7	1145·5	58·8

Mean 59 4
Assumed to be 1·457 volts.
Direct reading 313
Therefore ratio is $\frac{313}{59 \cdot 4}$ or 5·27.

Zinc and copper metallically connected. Zinc positive to copper.

1085·8	1054·0	31·8
86·2	1116·4	30·2
86·0	1054·6	31·4
85·8	1115·2	29·4
86·0	1053·9	32·1
85·6	1115·5	29·9
86·5	1056·5	30·0
87·2	1116·6	29·4

Mean...............30·52 or 0·749 volt.

Zinc and nearly pure saturated zinc sulphate (16°C.). Zinc negative to liquid.

1091·0	1104·7	13·7
88·6	1075·0	13·6
87·5	1100·2	12·7
86·7	1073·5	13·2
...	...	...
90·7	1075·2	15·5
91·2	1106·2	15·0

Cleaned zinc strip.

91·8	1075·1	16·7
91·0	1105·0	14·0
90·1	1072·1	18·0
90·3	1104·0	13·7

Mean............14·61 or 0·358 volt.

In the first four reversals the distance was a little too great.

Copper and nearly pure saturated zinc sulphate (16°C.). Copper negative to liquid.

1079·2	1075·2	4·0
78·2	80·2	2·0
78·7	74·5	4·2
79·2	83·2	4·0
80·5	74·8	5·7
80·0	84·5	4·5
80·0	74·1	5·9
82·0	86·0	4·0
81·8	74·6	7·2
81·2	85·8	4·6

Mean............4·61 or 0·113 volt.

Copper and distilled water (16°C.). Copper is positive to liquid.

1083·1	1081·0	2·1
82·8	86·0	3·2
82·9	79·6	3·3
82·5	84·2	1·7
82·6	79·2	3·4
82·2	85·7	3·5
82·5	78·9	3·6
83·2	86·0	2·8
83·4	79·8	3·6
83·9	86·7	2·8

Mean............3·0 or 0·074 volt.

Zinc and distilled water (16°C.). Zinc negative to water.

1083·0	1086·7	3·7
82·0	75·2	6·8
82·8	86·0	3·2
82·8	77·9	4·9
82·6	86·6	4·0
82·3	75·1	7·2
81·6	85·8	4·2
82·0	75·5	6·5
82·0	86·9	4·9
82·3	76·2	6·1

Mean............5·15 or 0·126 volt.

Copper and pure saturated copper sulphate (16°C.). Copper positive to liquid.

Zero.	Reading.	Deflection.
1085·0	1085·1	0·1
85·1	83·1	2·0
85·0	85·7	0·7
84·8	83·0	1·8
85·0	85·1	0·1
85·0	82·5	2·5
84·9	85·0	0·1
84·7	82·5	2·2
83·7	84·1	0·4
83·1	81·5	1·6

Mean............1·15 or 0·028 volt.

Nearly pure saturated zinc sulphate and pure saturated copper sulphate. Zinc sulphate is positive.

1083·0	1080·1	2·9
81·9	82·2	0·3
82·2	80·1	2·1
81·7	82·9	1·2
82·7	80·7	2·0
82·8	83·1	0·3
82·5	80·9	1·6
83·1	83·1	0·0
82·6	80·8	1·8
82·7	83·5	0·8

Mean............1·3 or 0·033 volt.

Distilled water and pure saturated copper sulphate (16°C.). Copper sulphate is positive.

1081·6	1077·2	4·4
82·1	84·7	2·6
82·0	78·9	3·1
82·2	84·9	2·7
83·0	80·0	3·0
83·5	86·0	2·5
84·0	80·8	3·2
83·0	85·1	2·1
82·5	79·8	2·7
82·3	84·8	2·5

Mean............2·9 or 0·071 volt.

(TO BE CONTINUED.)

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The 44th ordinary general meeting of the shareholders of the above Company was held on Tuesday, August 26, at the Cannon-street Terminus Hotel, under the presidency of Sir James Carmichael, Bart., the Chairman of the Company. The report of the directors for the half year ended the 30th of June last stated that there was a slight improvement over the previous half year, which was as much as could be expected under the protracted depression of commerce everywhere prevalent. The balance of the cost of repairing the cables referred to in the last report had entailed the necessity of applying to the Treasury for the full amount due under the guarantee. A telegraph conference had lately been held in London, at which the delegates of the various governments revised the rules and regulations affecting the international service, and determined to substitute a word tariff in Europe in place of the present system of charging the same sum for a message of twenty words, or less than twenty words. The Company's cables were in efficient working order. They recommended the payment of the usual dividend at the rate of 8 per cent. per annum on the preference stock, less income tax, and of a dividend at the rate of 3 per cent. per annum, free of income tax, on the ordinary stock, payable on and after the 1st proximo.

The revenue account stated that the receipts for messages during the half year had been £2,072, and the amount due from the Government under the guarantee was £3,600. The expenses at the offices and stations came to £1,877, the repairs of the Malta and Corfu cables to £2,140, and the amount available for dividends was £3,053.—The Chairman, in moving the adoption of the report, stated that he did not intend to detain them at any length, or to make any special observations, but he wished to call their attention to one subject—the Telegraph Conference. The Conference was held in London, and sat for some weeks, and the Company was represented at it by their secretary, Mr. Tombs. After considerable discussion, it was ultimately decided that a general word-rate should be adopted throughout Europe. This was a great change to make, and, as regarded its effect on the receipts of the Company, it was very difficult to predict, but his individual belief was that it would be beneficial to the Company, as small traders, those interested in the fruit, vegetable, and fish trades, would be more disposed to pay fifteen centimes per word instead of, as at present, so many francs per message of twenty words.—The Hon. Ashley Ponsonby seconded the motion.—Mr. Robinson suggested that some provision should be made to prepare against the termination of the subsidy.—The Chairman said if the shareholders were willing for this purpose to forego 50 per cent. of their dividend, the Board would have no objection. They would consider the proposal between this and next meeting. The report was then adopted, and the dividends recommended were declared. The retiring directors, Mr. Gurney and Captain A. T. Hamilton, were re-elected, as were also Messrs. Allwright and Robinson, the retiring auditors, and the proceedings then terminated in the usual manner.

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THE ELECTRICIAN.

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THE ELECTRIC LIGHT IN MINES.

England is so entirely dependent on her mineral wealth for her leading position as a manufacturing nation, and the obtaining of that wealth is attended by so many and great dangers, that any successful attempt in overcoming these dangers is welcomed as a national benefit. One of the greatest and most dreaded dangers in coal mines is fire-damp. The chemical composition of fire-damp is well known, as are the disastrous effects, direct and indirect, which attend its explosion in large quantities. But fire-damp, or marsh gas, only explodes when mingled with a certain proportion of oxygen, and by the application of a heated body at a very high temperature. The chemical formula for fire-damp is CH_4, *i.e.*, it consists of one atom of carbon (C) to four atoms of hydrogen (H). Now, in the explosion, the one atom of carbon takes up two atoms of oxygen, forming carbon dioxide (CO_2), whilst the four atoms of hydrogen take up two more atoms of oxygen, forming water ($2 H_2O$); so that say, one pound of CH_4 require for complete combustion four pounds of O. The air consists of about one part of oxygen and three parts of nitrogen, by weight; thus, ten pounds of air give two and a half pounds of oxygen. If, then, fire-damp is mixed with sixteen times its weight of air, it is one of the most dangerous explosive mixtures known, under any circumstances in which it is liable to come into contact with flame, or with ignited bodies at the temperature of flame. Hence, the methods employed to obviate the danger must be in one of two directions, viz., (1) to keep down the temperature of all bodies in the danger zone, or (2) to keep away oxygen and so prevent the formation of an explosive mixture. All experiments in the latter direction must probably fail; since as the men working in the danger zone require oxygen as their support of life. Air—*i. e.*, oxygen—is a necessity, and therefore the danger must be overcome from the other direction. The attempts in this way have been numerous, the best known being that of the Davy lamp, depending in its efficacy on the conducting and radiating power of metals. Colonel Shakspear, in his new lamp, prefers copper to iron as the metallic envelope, otherwise the efficacy of his lamp depends upon similar laws to that of Davy. M. André has, however, devised an electric lamp which seems to give what is required, viz., non-contact of high temperature bodies with the explosive mixture. Before describing this lamp, we may point out that a system which, if at all successful, is admirably adapted to mining purposes, has recently been described in our columns. We refer to the system of MM. Cebrian and Molera, in which the light may itself be generated at the top of the pit, in a perfectly innocuous position, whatever the gaseous state of the workings may be, and reflected by means of tubes and mirrors to the headings or any required point. In this case there is absolutely no point of high temperature in the pit, and, therefore, no explosion from this cause can possibly take place.

M. André's lamp consists essentially of four small carbon rods or pencils, enclosed in a series of vertical tubes. A light weight in each of these tubes above the carbon rod forces the latter down as its lower end is consumed. This weight is not heavy enough to break the point of the carbon, even when the point has become very fine, so that no unpleasant flickering occurs as the carbon descends, and no waste is occasioned. The arrangement of the carbon rods and the weights in tubes obviates the necessity for the strings required in other electric lamps working on the same principle of incandescence. The lower ends of the carbons rest upon discs of copper, which constitute the negative poles. The metal being incombustible, only one pole, the positive, is burned away. Hence, there not only results a saving of material, but the position of the point of contact remains invariable, and the resistance of the circuit is lessened. The copper discs are arranged in a peculiar manner, to be moved by the action of an electro-magnet, in order to prevent an interruption of the circuit from certain causes which are found to operate occasionally. One of these causes of interruption is the accumulation upon the discs of silicious dust from the impurities in the carbon. When the current is impeded by this dust, the disc turns slightly, and the point of the carbon sweeps the impediment away. The other cause of interruption provided for is the sticking of the carbon rod in the tube. This sticking rarely happens, but if the carbon rod fails to descend from this cause, the disc rises and breaks it away from its point of contact. By these means the circuit is restored.

This lamp is made air-tight, so that after the first short period of oxidation the incandescent carbons are in an atmosphere of carbon-dioxide (CO_2) and nitrogen (N), when, theoretically, the waste of carbon should cease. It is, however, found that a small waste continues, due, perhaps, to a disintegrating action of the current, forming an arc in addition

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to the contact effect. In this lamp, when the first carbon rod has been consumed, or if from any other cause the light becomes extinguished through an interruption of the circuit, the current passes automatically to the second of the series. This rod is then slowly consumed, like the latter portion of the first. From the second, the current passes in like manner automatically to the third of the series, and from this again to the fourth. The total duration ot the four carbons, which are each nine inches in length, is said to vary from 500 to 600 hours according to the strength of current used. Hence the cost of the carbons burned is but trifling, amounting to only about sixpence per lamp for that period of time; and the labour of keeping the lamps supplied with carbons is almost *nil*. As the automatic action of the commutator which switches the current from one carbon to the next in the series takes place whenever an interruption of the circuit occurs from any cause, there is no risk of the lamp being extinguished. The intensity of the light can, of course, be regulated by increasing or decreasing the lamps or resistances in circuit. One lamp would be sufficient for a "stall," however long, in longwall workings.

The question of expense is one that no theoretic considerations can determine. It would vary in each mine; unless, which is not likely, the conditions were absolutely similar. We are inclined to make one suggestion, which is, that in any attempt to introduce the electric light into mines the best known electricians should be consulted. Hitherto the management of the electric light has been practically in the hands of amateurs—with the result that on the Thames Embankment and elsewhere, after an unnecessary expenditure, they are beginning to find out what half-a-score of electricians could have told them in five minutes twelve months ago. These results, too, are echoed abroad as wonderful achievements. We look upon them as proofs of the absurd manner in which so-called practical men go about their business.

The introduction of the electric light into our mines, if it can safely be accomplished, is worthy of national as well as individual consideration, and some part or all of the four or five thousand pounds annually voted for scientific researches might well be directed to experiments in this direction. What say the present recipients of the money to this?

THE TELEPHONE: ITS APPLICATION FOR BUSINESS AND OTHER PURPOSES.

The following correspondence has appeared in *The Times*:—

TELEPHONIC EXCHANGE.

SIR: In reading your account in *The Times* of to-day of inventions to be exhibited at the meeting of the British Association, I notice a reference to the telephonic exchange system, and am led to ask how much longer it will be before this most useful arrangement is established in London? To any one who has visited the United States, and seen how very generally the telephone is used by business men it is a matter of surprise why so simple a thing as this telephonic exchange is not adopted here. I am convinced that a well-organised and cheap system would answer admirably.

There is also in New York a good arrangement for self-acting electric burglar alarms, by which any safes, doors, or windows of banks or warehouses may be placed in communication with one central office. This has been found to be well adapted to the necessities of the American city, and might be of service in certain cases here, although the superiority of our police force renders it less needful for us.—I am, Sir, yours faithfully,

GEORGE H. CHUBB.

128, Queen Victoria-street, Aug. 19.

SIR: With reference to Mr. Chubb's letter in *The Times* of to-day, I beg leave to inform you that this company is now erecting a Telephone Exchange in the city, which will shortly be succeeded by others in different parts of London, and in the other large towns of the United Kingdom.

Mr. Edison has lately given the subject of Telephone Exchanges his earnest attention, and has devised means, at once efficient and simple, which supersede the noisy and expensive system prevailing in the central bureaux in the United States. It is true that, as Mr. Chubb implies, the English commercial public are at present behind the age in respect to telephonic communication; but the Edison exchanges now being organised by this company will surpass in cheapness and efficiency anything of the kind known in America.—I am, Sir, your obedient servant, ARNOLD WHITE, Secretary and Manager.

The Edison Telephone Company of London (Limited), Aug. 20.

SIR: In reply to the very reasonable question of Mr. George H. Chubb on this subject in *The Times* of to-day, in the absence of the chairman of the Telephone Company (Limited), I may state that the delay has to a great extent been caused by the difficulty in obtaining the improved instruments most suitable for the purpose. Now that this has been overcome progress has already been made in the direction of establishing the central office system, not only in London but in some of our most important provincial towns.—I am, Sir, your obedient servant,

The Telephone Company (Limited). ALLAN MORRISON.

SIR: For some time I have had a Post Office "private wire," with the Wheatstone A B C instruments attached, between my two establishments in this town. Last year I hired for three months a complete set of Bell's telephonic apparatus, and used it instead of the A B C instruments. The advantages proved so great that for business purposes one is astonished that the old-fashioned A B C is not at once superseded. The difference is this —a conversation in one case is actually spelt through very deliberately by the two parties in communication; in the other, it is spoken as rapidly as you wish to speak the words. Not liking to go back to the use of the A B C, I applied to the Post Office to be allowed to have two telephones supplied in lieu of the Wheatstones, but the Department declined, saying they were prepared to supply telephones in addition to the instruments at an increased rental of £11 per annum. This I could not afford, nor was it what was wanted, and I again applied for a readjustment of their contract whereby I could hire the use of the line wire only for a certain term and supply my own telephones. This also was refused, and I have therefore no alternative but to continue the use of an instrument which for quick communication is far behind the telephone. May not this account in some way for the slowness shown in adopting the telephone, and to the difficulty there would be in the establishment of any system similar to the American mentioned in Mr. Chubb's letter of to-day, as many firms are already bound to the use of the Wheatstone for terms probably varying from two to ten years? Could not, however, the Telegraphic Department meet those who wish to use the telephone, so that they might do so without actual loss to the revenue or themselves, but to the great advantage of many who, having practically proved its superiority, are ready to adopt it?—I am, sir, yours obediently, R. P.

Tunbridge Wells, Aug. 20.

SIR: I am pleased to find from the two replies in *The Times* of to-day to my inquiry that the Telephone Exchange is in course of adoption, and that one company has actually got it at work. By the courtesy of Captain Home and Mr. Ormiston, of the Telephone Company (Limited), I have to-day seen the whole of their arrangements and instruments at work, and can testify to the perfect ease and simplicity in speaking through the central office to any one who has a telephone in communication. The delay in perfecting the system seems to have arisen from the difficulty in obtaining permission to lay wires—a hindrance probably overcome in America by not asking permission at all—and from a laudable desire not to start the work until the instruments had been perfected, which end appears now to have been attained. It only remains for business firms and banks to take the matter up and avail themselves of its advantages. We must not complain of successful American competition and yet refuse to adopt such aids to doing business as tend to this success.—I am, Sir, yours faithfully, GEORGE H. CHUBB.

128, Queen Victoria-street, Aug. 21.

ERRATUM.—Mr. D. G. FitzGerald writes:—"The incautious insertion of an explanatory sentence has made nonsense of one portion of my letter in your last issue. The word 'latter' in the ninth line of second column, p. 163, should be deleted, and the word 'jar' substituted for it."

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RADIANT MATTER.*

BY WILLIAM CROOKES, F.R.S.

To throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was 24 years old, and at this early period of his career he delivered a series of lectures on the General Properties of Matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression "Radiant Matter":—

"If we conceive a change as far beyond vaporisation as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of Radiant Matter; and as in the last conversion many qualities were lost, so here also many more would disappear."

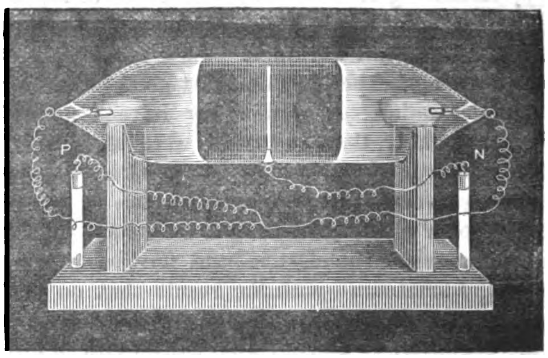
Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of Radiant Matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.†

If, in the beginning of this century, we had asked, what is gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further, *i.e.*, decreasing the number of molecules in a given space and lengthening their mean free path, the experimental results are obtainable to which I am now about to call your attention. So distinct are these phenomena from anything which occurrs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path. Radiant Matter.

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction-coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavour to render this "dark space" visible to all present. Here is a tube (Fig. 1), having a pole in the centre



in the form of a metal disc, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little on each side of the negative pole in the centre. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing towards that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his Address at Dublin:—

"In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure."

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time in comparison to the misses may be disregarded, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and radiating from the pole with

---

* A lecture delivered to the British Association for the Advancement of Science at Sheffield, August 22, 1879.

† "I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philosopher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

"As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and colour frequently give way to a colourless transparency, and a general mobility of particles is conferred.

"Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in colour that were left, are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, colour, elasticity and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of colour.

"To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favour. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which Nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form."—"Life and Letters of Faraday," vol. i., p. 308.

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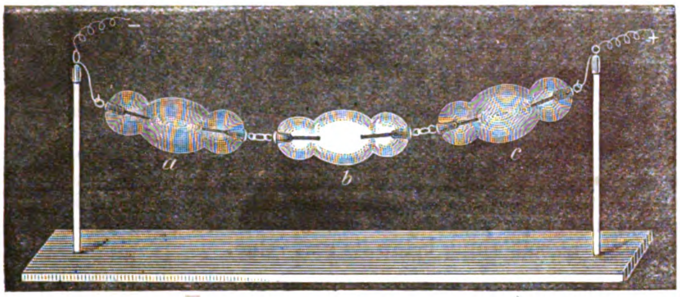
enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of Radiant Matter.

Radiant Matter exerts powerful phosphorogenic action where it strikes.

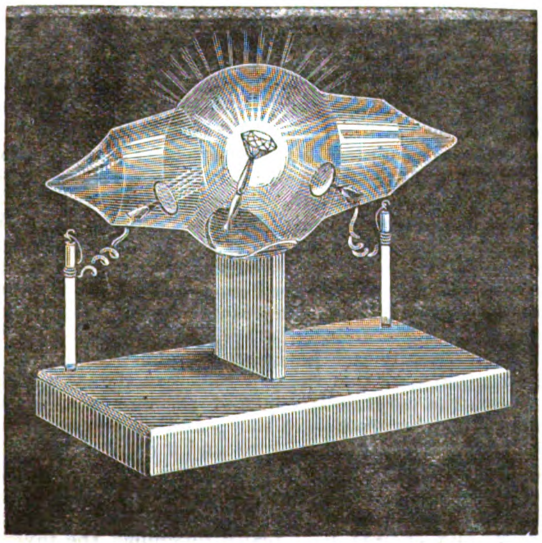
I have mentioned that the Radiant Matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of Radiant Matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colours are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs composed of different



glass; one is uranium glass (a), which phosphoresces of a dark green colour; another is English glass (b), which phosphoresces of a blue colour; and the third (c) is soft German glass,—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green.

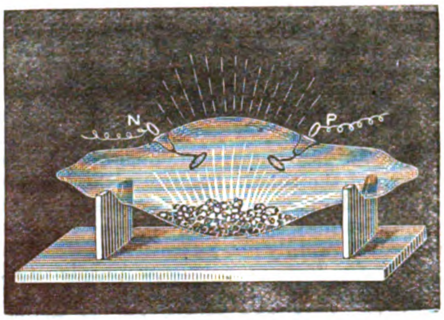
My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candlelight—it phosphoresces for hours with a bluish white colour. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. The rare mineral Phenakite (aluminate of glucinum) phosphoresces blue; the mineral spodumene (a silicate of aluminium and litium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond, green by daylight, colourless by candlelight. It is mounted in the centre of an exhausted bulb (Fig. 3), and the molecular dis-



charge will be directed on it from below upwards. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 4) is a fine collection



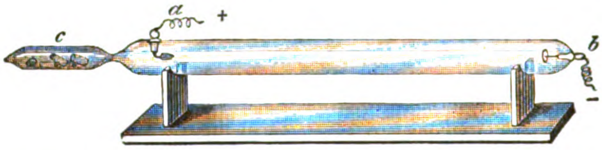
of ruby pebbles. As soon as the induction spark is turned on you will see these rubies shining with a brilliant, rich red tone, as if they were glowing hot. It scarcely matters what colour the ruby is, to begin with. In this tube of natural rubies there are stones of all colours—the deep red and also the pale pink ruby. There are some so pale as to be almost colourless, and some of the highly-prized tint of pigeon's blood, but under the impact of Radiant Matter they all phosphoresce with about the same colour.

Now the ruby is nothing but crystallised alumina with a little colouring matter. In a paper by Ed. Becquerel,* published twenty years ago, he describes the appearance of alumina as glowing with a rich red colour in the phosphoroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red colour.

The spectrum of the red light emitted by these varieties of alumina is the same as described by Beçquerel twenty years ago. There is one intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6,895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favourable than any other for the development of the properties of Radiant Matter which are now under examination. Roughly speaking, it may be put at the millionth of an atmosphere.† At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass.‡

I have here a tube (Fig. 5) which will serve to illustrate the



dependence of the phosphorescence of the glass on the degree of exhaustion. The two poles are at a and b, and at the end (c) is a small supplementary tube connected with the other by a narrow aperture, and containing solid caustic potash. The

* "Annales de Chimie et de Physique," 3rd series, vol. lvii., p. 50, 1859.

† 1·0 millionth of an atmosphere	=	0·00076 millim.
1315·789 millionths of an atmosphere	=	1·0 millim.
1,000,000· ,, ,, ,,	=	760·0 millims.
,, ,, ,, ,,	=	1 atmosphere.

‡ Nearly 100 years ago Mr. Wm. Morgan communicated to the Royal Society a Paper entitled "Electrical Experiments made to ascertain the Nonconducting Power of a Perfect Vacuum, &c." The following extracts from this Paper, which was published in the Phil. Trans. for 1785 (vol. lxxv., p. 272), will be read with interest:—

"A mercurial gage about 15 inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tinfoil 5 inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern, the whole was cemented together, and the air was exhausted from the inside of the cistern through a valve in the brass cap, which, producing a perfect vacuum in the gage, formed an instrument peculiarly well adapted for experiments af this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted) the coated end was applied to the conductor of an electrical machine, and notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage."

"If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the colour of the electric light, which in air rarefied by an exhauster is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be

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tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and injure the vacuum. Exhaustion has then been recommenced, and the alternate heating and exhaustion repeated until the tube has been brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly and liberate a trace of aqueous vapour. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear, which rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapour, which the heat had driven off, is re-absorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel towards the potash tube. Now a a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but I should detain you too long, as time is required for the absorption of the last traces of vapour by the potash, and I must pass on to the next subject.

(TO BE CONTINUED.)

nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air having found its way into the tube, the electric light became visible, and as usual of a green colour; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually produced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum."

"This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; that if they are brought within a certain distance of each other, their conducting power begins, and continually increases till their approach also arrives at its limit."

SUBMARINE TELEGRAPH PROPERTY.

The present position of submarine telegraph property is, says *Herapath's Journal*, in our judgment, scarcely what it should be, having regard to its intrinsic merits. Thus, while Brazilian Five per Cents or Russian Five per Cents, which repose entirely on the good faith of the empires of Brazil and Russia, command quotations of from 85 to 90, the shares of the Eastern Telegraph and the Eastern Extension, Australasia, and China Telegraph Companies—upon which 5 per cent. per annum is paid with exemplary regularity—stand at barely 80 per cent. of their par value. The shares of these companies have, indeed, been hardening in price of late, and they now stand at £7¾ or £8 per share (£10 per share paid); but why should they not be at £8 10s. or even £9 per share? There is one consideration which appears to us to tell strongly in favour of an affirmative answer to this question. This is the fact that the dividends declared are not at all the result of any straining of the accounts, but could be increased without much difficulty, if the Directors and Shareholders chose to increase them. Another consideration which also tells in favour of the Eastern and the Eastern Extension Telegraph Companies is the rapid growth of our commercial relations with India and Australasia, and especially with Australasia. Great nations are being built up at the Antipodes, and these two telegraph Companies must, in spite of some present checks and disappointments, profit materially from their development. We can but think, then, that Eastern and Eastern Extension £10 shares ought really to be at £8 10s. or £9 per share each, with a chance and prospect of a still further augmentation in value.

When we come to deal with the Anglo-American Telegraph Company the prospect is less encouraging. The company has in fourteen years of a rather chequered history bought up in succession the undertakings of the Société du Cable Français and the Direct United States Cable Company. Now it appears destined to make a similar purchase of a new French Trans-Atlantic Telegraph Company inaugurated by M. Pouyer-Quertier. No doubt this new enterprise will profit by the experience of its predecessors, and will be enabled to avoid the mistakes which they have committed. M. Pouyer-Quertier and his associates will by laying two cables also bring to bear against the Anglo-American Company the most formidable competition which it has yet had to sustain. Still, by reducing its rates to one shilling, or say ninepence per word, the Anglo-American Company must render the efforts of the Pouyer-Quertier Company almost, if not altogether, profitless; and after a time these French intruders upon the domain of the Anglo-American Company will, in all probability, be disposed to follow the example of the Socièté du Cable Français. If they do so, the position of the Anglo-American Company will, after all, be strengthened, as it may obtain possession of two new cables at what shopkeepers occasionally term "an alarming sacrifice." Without anticipating the future too much, we may remark that one encouraging circumstance is established in the recently issued report of the Anglo-American Directors. We refer to the announcement that the Anglo-American Company's renewal fund—a renewal fund accumulated, be it remembered, in three or four years—has now attained an importance which enables the Company to utilise the shore ends of one of its abandoned cables, and so to re-endow itself with what will be virtually a new cable. The Anglo-American Company has been regarded by many as an undertaking which devoured its capital with alarming rapidity; but the Company has now proved its ability to virtually renew a cable in say four years, and this does really seem to give the undertaking more permanence and stability than it has been supposed to possess. Upon the whole, it appears to us that, having regard to the increasing employment of telegraphic communication throughout the world, submarine telegraph property is now appreciated upon the Stock Exchange at something below its real value.

BRITISH ASSOCIATION.

THE WRITING TELEGRAPH.

On Monday, before the Mechanical Section, Mr. E. A. Cowper described details of the construction of his writing telegraph and the mode in which a pen at a distant station was made to write freely, as the operator at the sending station wrote with a pencil at the sending instrument. He explained the necessity that existed for causing the two currents of electricity that conveyed the power to the distant station to increase steadily and gradually without any sudden large increase or decrease of resistance being opposed to such currents; the construction of the necessary resistances being practically that of one very long thin German silver wire, having 32 metal plates soldered to it at the proper intervals, such plates being all brought very close together with simply a thin sheet of paper with paraffin between them, so that a contact rod in connection with a battery with a small knob or projection on it could slide over the tops of the plates and make contact with each one in succession. Then two such contact rods joined to the pencil of the operator and placed at right angles to one another worked over the tops of the two separate sets of contact plates, each set affecting one line wire, so as to give latitude and longitude of the pencil of the operator at all times. The quick action or perfect response of the needles at the receiving instrument, which directly controlled the writing pen, was obtained by using exceedingly thin soft iron plates, both for the needles and for the magnets which affect the needles, so as on the one hand to have the least possible amount of momentum and *vis inertia* in the needles, and the least possible residuary magnetism in the magnets. The needles were slightly curved in their section to stiffen them, their thickness being only 1-110th inch, and were mounted on polished hard steel bearings, and were thus exceedingly free and lively, as a very small amount of friction or weight in this part of the instrument would be fatal to good writing. The power of the needles was ensured by fixed flat coils that surrounded them, brought into action by a local battery, whilst the two line wires were coiled around the fixed magnets that affected the needles and attracted them more or less as the strength of the currents varied. Then the needles being at right angles to each other, pulled the pen in the two directions, vertically and horizontally, and also pulled against two light springs, so that the pen took exactly the varying positions due to the varying strength of the currents, which again depended upon the position of the pencil of the operator. The paper on which the operator wrote and the paper on which the pen wrote at the opposite end of the line both moved along by clockwork, so as to write a long continuous message or telegram.

Mr. Cowper exhibited his machine, which was carefully examined, and showed how really ingenious the inventor had been. In answer to questions, he said that the instrument had worked perfectly at a distance of 99½ miles. At present the operator could send messages at the rate of twenty words per minute, but he hoped that would be increased.

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BRITISH ASSOCIATION.

ELECTRICITY AS A MOTIVE POWER.*

We hear on all sides now complaints regarding the stagnation of trade, the competition of foreign labour, and the difficulty found in disposing of English products to other countries. Various are the remedies suggested. On the one hand we are told that protection is the cure, because our trade is now almost entirely an import one, kept up by the export of English gold, and not, as it should be, by an exchange of English commodities for foreign ones. Consequently, there are some people who say that the only way to induce other nations to lower their prohibitive import duties, so as to stop this one-sided traffic, is to cause their own goods, now freely exported to Great Britain, to hang on their own hands, and that this can be done by the English temporarily also adopting protection. On the other hand, we are assured that emigration is the panacea, and that it is the strikes which ruin the country.

But while the one side is maintaining, and the other side stoutly denying, that commercial depression can be cured by legislation, we are apt, far too apt, to forget that there exists a means by which, without lessening the wage of the workman, or the profit of the master, the cost of production can be diminished, prices lowered, and the failing trade of England resuscitated.

For it is only by burning coals that we can hammer our steel, turn our grindstones, work our lathes, and propel our trains? Coal is, no doubt, an extremely useful servant, but it is one that here in Yorkshire costs you five shillings a ton when you want to get power out of it, about twelve shillings a ton when used for melting metals and making gas, and about ten shillings a ton when you want it to warm your houses; therefore, as Mr. Bainbridge has been so kind as to ascertain for us that roughly in Sheffield alone about 500,000 tons are used annually for the first purpose; 750,000 tons for the second; 150,000 tons for the third; and 250,000 for the last of these objects, you see there is altogether an annual consumption in this town of about one million six hundred thousand tons, costing you therefore about £790,000 every year.

It is worth while, then, considering whether this consumption of coal can, even in a small degree, be replaced by any other source of power and heat.

For example, at Ottawa, in Canada, where exist perhaps the largest wood-cutting works in the world, the logs of wood come down from the mountains, are collected in the river, lifted and placed in position on the benches, sawn into planks, and stacked; but not a pound of coal is burnt. For merely by taking advantage of the fall of water which exists at the place, a man has merely to turn on a particular water tap to perform any particular operation.

For a stock of water on a hill is, to the people in the valley, what a coal mine is to a Sheffield manufacturer. As the water runs down the hill it can turn wheels, it can work machines just as can coal as it burns in the furnace of a steam engine. You all know the water wheels round Sheffield employed to work the grindstones and the tilting hammers. The high quality of the anvils coming from your Mousehole Forge, where water-power is, or was, exclusively used, would be alone sufficient to keep water-power permanently before you.

On Goat Island, between the Falls of Niagara, there is a paper works, the machinery of which is worked by the Falls. But what an infinitesimal portion of the energy of these falls is used by that single paper mill. For, in addition to the gradual slope of the river, on account of which the water acquires considerable velocity, a hundred million tons of water come tumbling down every hour, through a vertical height of 150 feet. Now the power this represents is, of course, the same as would be required by perfect pumps to pump it back again. To raise a hundred million tons of water per hour, through 150 feet, requires the expenditure of nearly seventeen million horse-power; and this could only be produced, with even good steam engines having much above the average efficiency, burning, say only 3lbs. of coal per hour per horse-power, by an annual expenditure of about two hundred million tons of coal, which is about equal to the total consumption of coal throughout the whole world. And if it be remembered that there exist in the world other waterfalls besides Niagara, that we have also innumerable rapidly flowing rivers, the important fact well known to scientific men, but one which it is difficult to induce the world at large to grasp, stares us in the face—that we obtain, in a laborious way from the depths of the earth, the power we employ, and we let run to waste, every hour of our lives, many, many times as much as we use.

But it is not every manufactuory that is situated directly over a stream, or even near a stream; and even when that is the case, as in Sheffield, you find streams are sometimes fickle, the tilting cannot be regulated with the same nicety as with a steam hammer—the natural order of things is reversed; water gives way to fire.

But were it possible, without water courses or cumbrous mechanism, to transport direct the energy of the mountain torrent, then machines in the very heart of a town could be worked as economically as those close to cataracts.

Again, even in a perfectly flat country, where waterfalls are unknown, the question of economic transmission of energy has no less interest. For you know that large steam engines can be worked much more economically than small ones. If, for example, I have a steam engine of many hundred horse-power, it can be worked by an expenditure of about two, or two-and-a-half, pounds of coal per horse-power per hour, or, at the present price in Sheffield for steam coal, five shillings per ton, the best steam engines, if they be very large, can be worked at considerably less than one farthing per horse-power per hour. But if a man has a small grindstone requiring, say one horse-power to work it, and if he uses a small steam engine for this purpose, then, instead of costing him less than twopence per day of eight hours' work, he will probably have to pay a shilling a day, in addition to the expense and trouble of getting up the steam; so that, if he only uses the small steam engine occasionally, it will be hardly worth while going to the expense of having one at all. If, however, he could have transmitted to him, just at the time he might require it, a small amount of energy at, say, one halfpenny per hour per horse-power, which would be three or four times the actual cost of production of the horse-power with a very large steam engine, and if he could turn off the power, like gas, when he did not want it, so that one single hour's work with a one horse-power grindstone cost really only one halfpenny, how many of the smaller workmen of Sheffield would be glad to avail themselves of such a facility?

But you will say, in our large factories, in our huge cotton spinning mills in Manchester, for example, we do use very big steam engines, and, therefore this transmission of energy cannot produce any great gain there. Undoubtedly, these steam engines are fairly efficient, because they are so large; but what about the enormous mass of shafting used to connect this single engine with all the stories of the factory and with all the machines in each story? Why, the waste of power in friction in this shafting is so great that, in spite of the extreme inefficiency of small engines, it has been proposed, as an economical measure, to replace the one large steam engine by many small ones, each driving two or three machines direct.

It might, at first sight, appear that the water already brought to our houses for drinking and for cleansing purposes, might be also used there for working small turbines or waterwheels, and I have heard this suggested as a possible means of utilising a natural source of power. But this is one of those delusions into which over sanguine people are liable to fall. For there are very few towns where the working pressure of water in the streets is more than able to raise it to a height of 100 feet.

Now 1 cubic foot of water weighs 62½ lbs.
therefore 1 ,, ,, ,, descending 1 ft. per minute does approximately 1 foot pound of work per second.
That is— 5½ cubic feet of water per minute } for every 100 feet
Or— 330 ,, ,, ,, ,, hour } head
produce approximately 1 horse-power.

Some allowance must, however, be made for the fact that our best turbines have at the most only an efficiency of 0·8, that is waste 20 per cent. of the power. We may, therefore, say that practically about
450 cubic feet of water per hour } for every 100 feet
Or—2,700 gallons ,, ,, ,, } head
produce 1 horse-power.

But even in places like Sheffield, where the supply of water is large, the minimum cost in the town, when more than seventy millions of gallons are used annually, is not less than 6d. per 1,000 gallons. Consequently, with water at a pressure of 100 feet, it would cost about one shilling and fourpence per horse-power per hour.

In Sheffield, where the working pressure of the water in the lower parts of the town is also unusually high, being not less than 130lbs. per square inch, or 300 feet head, it would be possible to produce work by small turbines at about fivepence per horse-power per hour; but this, of course, cannot be compared with less than one farthing per horse-power per hour—the cost of working very large, good steam engines.

In our poverty and depression, our old servant, coal, is beginning to desert us, and to demand a higher price than we can give. Water, a yet older handmaid, refuses to work at all in our houses except for extravagant payment. Where is it that we must turn for help? Where can we find the carrier that will, at a small cost, transport our motive power over long distances?

It is to electricity we must look for an answer to this question. It is to that fleet, subtle messenger to whom we trust the carrying of our news, that we must trust the carrying of our motive power.

To explain better what I mean:—when I turn the handle of this machine my muscular energy is turned into electricity. This electricity is conveyed by the two wires before you to the small motor at the other side of the hall, where it is converted back again into work. I put in work, then, here and I get it out again at a distance, without any shafting, straps or pipes connecting the two places.

In exactly the same way, but on a much larger scale, Mr. Wilson will be so kind as to polish a knife with motive power supplied by Messrs. Walker and Hall, of Howard-street, and conveyed here electrically, by wires suspended to the spire of St. Paul's Church, and crossing the streets as you see them in this diagram.

This other diagram shows you exactly how the machines in Howard-street, and these on this platform are electrically connected together.

Now these machines that are employed for this purpose depend on two important discoveries, the first, supposed to have been made by Romanosi, in 1802, who found that an electric current could produce mechanical motion; the second discovery, made by Faraday, in 1831, who, after the most patient investigation, was at length able to prove conclusively the result that he had long felt in his own mind must certainly be true—viz., that a magnet must somehow be able to produce an electric current. The first of these discoveries may be illustrated by the following simple experiment. Here we have a vertical copper wire, through which we can send an electric current either upwards or downwards. Behind the wire there is a magnet, suspended on a horizontal axis, so that it can turn in a vertical plane. The magnet is so arranged, that usually it stands upright, but if I send a current upwards, you observe the marked end turns to your left, while if I reverse the direction of the current, the marked end turns to your right, the magnet in both cases placing itself at right angles to the wire. Now, why does the magnet move when the current flows along the wire? Because the wire with the current in it produces in the space surrounding it the same effect that would be caused by the presence of a large magnet. For if I hold this other magnet in this position, perpendicular to the suspended magnet, you see the latter one turns with its marked end towards your left hand, as it did when the current ascended; and when I reverse the position of the big magnet, the smaller one puts itself in the same position as it did when the current descended. From this you would anticipate that since an electric current can act like a permanent steel magnet, in deflecting a suspended magnet, and since a steel magnet can make this piece of soft wire into a magnet by being put near it, that an electric current will also make a piece of iron into a magnet, a result first proved experimentally by Arago. When the electric current passes through this coil of wire, wound round this iron bar, the bar acquires the power to hold up masses of nails, but the moment the current ceases the iron, as you see, loses almost, but not *quite*, instantaneously, all its magnetic properties, and the nails fall to the ground. But since, by electricity, I am able to produce sufficient pulling force to hold up bits of iron, or, at will, cause this force to cease to act, then I must be able to do just as Newcomen did, when he made his so-called atmospheric engine.

* A Discourse delivered to the Working Men of Sheffield, August 23rd, 1879, by Prof. W. E. Ayrton.

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For if we cause the attraction of this electro-magnet to pull a piece of iron, or armature as it is called, against the tension of a spring, and if, just when the iron is almost touching the electro-magnet, we interrupt the current, the spring will be able to pull the iron back again, and thus by repeating the action over and over again you see we can get an oscillating motion similar to that obtained in a single acting engine. And any oscillating motion you know can be turned into a rotatory motion by means of a crank and a fly-wheel to make the crank pass the dead points. Now, the first man to make an oscillating electro-motor of this kind was a learned monk of Padua, Salvator del Negro, in the year 1831. But an oscillating motion has many disadvantages, of which perhaps the most important in an electric engine is that the moving armature at the end of its stroke will be at a distance from the electro-magnet. Now, the electro-magnetic attraction diminishes very rapidly as the distance increases, so that when the armature begins to approach the electro-magnet there will be very little force pulling it.

The Russian philosopher Jacobi explained this in 1834, and devised a rotatory engine in which the moving parts were not merely pieces of iron but electro-magnets like the fixed ones. When the pole of one electro-magnet was approaching that of another due to the rotation of the apparatus, the currents were so arranged that there was attraction, but the moment the moving pole passed the fixed pole the electric current flowing round the former was reversed, so that there was attraction. An instrument such as Jacobi used may be seen working on the table, and like Jacobi's was originally intended to propel a boat. Here again I have a complete model boat driven by an electro-magnetic engine, with galvanic battery in the boat. A third electro-motor is working a Howe's sewing machine, while a fourth is a small engine running round on a pair of metal rails. This last would no doubt pass with the world as a mere toy, but the practical philosopher sees foreshadowed in it his dream of the future, just as Stephenson, in his "Puffing Billy," no doubt foresaw the express locomotive engine of the present day.

But after some time Jacobi abandoned his electro-motor, as the fuel cost far too much. Why then trouble you with considerations regarding electro-motors? Because we have since learnt why the old form was such an expensive producer of power, and what is the proper duty in which electro-motors should be employed.

Now, it was this very question :—can an electric engine be made to work more economically than a steam engine, that first attracted Joule of Manchester, in 1843, to commence that all-important investigation, which lasted for six years, the determination of the mechanical equivalent of heat.

Formerly, electric currents were almost entirely produced only by galvanic batteries, such as I have in my hand, in which zinc is burnt just as in the furnace of a steam engine coke is burnt. The amount of heat that could be got from burning a pound of zinc could be ascertained in the same way as the amount of heat produced by the burning of a pound of coal, but the fact that the latter was about seven times the former was of little value in the science of electro-motors, until Joule had proved that a certain quantity of heat is always equivalent to exactly the same quantity of work, no matter how the heat be produced ; in fact, until Joule had arrived at that famous result which, although you know it well, will still bear repeating, that result which made the "Conservation of Energy" a law and not merely a speculation.

A quantity of water on a height, a heated body, a moving mass, two separated quantities of opposite kinds of electricity, an electric current, two chemicals which would combine if brought together, particles of attracting matter at a distance asunder, two planets in space, are examples of examples of energy—each of the systems can be made to do work.

Now, experience shows that all these energies are convertible into heat, and that a certain quantity of each kind of energy is mechanically *exactly* equivalent to a certain quantity of any other. If a body, or if a system of bodies, possesses different kinds of energy, then as long as no energy leaves the system, or enters it from without, this sum is *perfectly constant*, no matter how one of these forms of energy may change into another form. Energy is, in fact, as indestructible as matter, and this law has one of its proofs in the long unsuccessful search for a perpetual motion.

Since, therefore, a pound of ordinary coal burning gives out seven times as much heat as the burning of a pound of zinc, we may say at once that a steam engine would give seven times as much work as an electric engine for equal weights consumed, if in both cases all the heat could be turned into work ; or, since zinc is about twenty-four times as dear as coal, that a steam engine would be about 150 times as economical as an electro-motor, worked by a battery.

But so far we have only considered the law of "Conservation of Energy." There is, however, another, and no less important principle, called the "Dissipation of Energy ;" and this law tells us that, although the energy of a system cannot by itself increase or diminish, yet our power to convert one form of energy into another is continually growing less, our stock of available energy is gradually failing. Our mountain lakes, our vast store of coal, are practically useless until either the water is set in motion rolling down the hillside, or until the particles of the coal are set in rapid vibration as it slowly burns ; energy of position, energy of chemical affinity, are of no use to the manufacturer until turned into kinetic energy or energy of motion. But from friction of various kinds, whenever energy exists in the kinetic form, some portion of it is being continually converted into heat. Whenever man or nature utilises energy, it must be first turned into some kinetic form, and whatever be the aim of the special machinery employed, some of this energy passes into heat. We cannot make even a clock go without regular winding up, although the only useful work done by the clock is to turn its hands at regular speeds ; the earth's energy of rotation is now, like the moon's in past ages, gradually growing less, and is being converted into heat on account of tidal retardation ; the earth, moon, and sun, and all the planets are losing their energies of motion and relative positions, to be all ultimately turned into heat.

But, at any rate, it will be said there will still remain the heat, and since heat can be converted back into other forms of energy, we shall be none the worse off. But it must not be forgotten that, whenever heat is produced, some passes off by conduction through even our best non-conducting substances, and by radiation into space from even our best non-radiating surfaces ; and this conducted and radiated heat, although it may impart some trifling warmth to unseen worlds, is for the greater part entirely lost to our universe. And even were it not so, even had we perfectly non-conducting coatings and perfectly non-radiating surfaces—had we, in fact, the most perfect heat engine that our study of the science of heat would lead us to believe theoretically possible, one with no friction, no loss of heat by conduction through the sides of our cylinders, and no radiation from their surfaces—still our power to convert heat into other forms of energy would be very limited. For if there are two bodies one hotter than the other we can employ an engine, like a steam engine, to convert part of the heat in the hotter one into some other form of energy ; but the amount of heat converted, with even this ideal perfect engine, will, with such temperatures as are met with in practice, only be a fraction of what necessarily passes through the engine from the hot body to the cold, and warms up the latter ; and as our whole power of conversion of heat into work depends on the difference of temperature, we lose it altogether when we have brought all parts of a system to the same temperature, no matter how high this temperature may be.

It is not, therefore, sufficient to say that the burning of a pound of coal produces seven times as much heat as the burning of a pound of zinc ; but we must consider what fraction of the heat thus produced is converted into useful work in a heat and in an electric engine respectively.

As already mentioned, our most perfect steam engines can be made to produce one-horse power with the consumption of 2lbs. of coal per hour. Now, the burning of 2lbs. of coal will produce enough energy to raise 18,528,000 pounds one foot, or will produce 18,528,000 foot pounds of work. Now, one-horse power is equivalent to 1,980,000 foot pounds of work per hour ; therefore, as regards the total energy in coal, even our best steam engines only utilise 2-9ths of it, and waste 7-9ths. But, as already mentioned, even a perfect engine cannot, with the ordinary temperature available utilise the whole of the heat of the fuel. In fact, theory tells us that the efficiency of a perfect heat engine, or the ratio of the work done to the maximum work obtainable from the consumption of the fuel, is equal to the ratio of number of degrees of temperature through which the steam is cooled in doing work to the highest temperature of our steam, when we take as our zero of temperature a point 460° below the ordinary zero of the Fahrenheit scale.

Now, in our best steam engines, the steam, when it begins to push the piston by expanding, has a temperature of about 300°F. and at the end of the stroke a temperature of 100°F. so that the efficiency of a perfect ideal engine working between these temperatures, is only about ¼, not so very much greater than that of best practical engines.

(TO BE CONTINUED.)

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Aug. 27.		Business Done Week Ending Aug. 27. Highest.	Lowest.
Anglo-American Ordinary	52¾,	3¼	53¼	52¾
Do. "B"	82,	½	82½	82⅛
Do. "A"	26¼,	¾	26¾	26⅝
Brazilian	6¾,	7	7	7
Cuba	7¾,	8¼	8 3-16	7⅞
Do. Ten per Cent. Preference	15¾,	16¼	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	11⅝	11⅛
Direct United States	10,	½	10¼	10⅛
Eastern	7 13-16,	15-16	7 15-16	7⅞
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do	101,	103	102½	101⅞
Do. Six per Cent. Preference	11 15-16,	12 1-16	12	12
Eastern Extension	7¾,	⅞	7 15-16	7 13-16
Do. Six per Cent. Deb.	105,	108	107½	106¼
German Union	7½,	8	—	—
Globe Telegraph and Trust	4¾,	5	5	4⅞
Do. Six per Cent. Preference	11,	½	11½	11
Great Northern	8⅝,	⅞	8⅞	8½
Indo-European	21,	22	21½	21¼
Mediterranean Extension	2¾,	3¼	3	2 13-16
Do. Eight per Cent. Preference	9¼,	¾	—	—
Reuter's	9,	10	—	—
Submarine	220,	225	—	—
West India and Panama	1,	½	1 15-16	1¼
Do. Six per Cent. Preference	6¾,	7	7½	6⅞
Western and Brazilian	3,	½	—	—
West. Union Seven per Ct. 1st Mt.	118,	122	121	121
Do. Six per Cent. Sterling	107,	109	108¼	108

TRAFFIC RECEIPTS FOR JULY, 1879.

Companies.	July 1879.	July 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,608	192	—
Direct Spanish Telegraph Company	913	812	101	—
Direct United States Telegraph Company	16,440	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	23,411	24,927	—	1,516
Great Northern Telegraph Company	20,421	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	725	—	—	—

INSULATED COPPER WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handled Cord, Silk Cord for Electric Bells, &c.—J. and W. RICKARD, Insulated Wire Manufacturers, Derby.

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NOTES.

Nickel-Plating.—It is said that the Anglo-American Nickel-Plating Company, of Buckingham-street, Birmingham, have introduced some new and improved dynamo-electric machines for nickel-plating purposes.

Ærolites.—During a recent thunderstorm a number of ærolites fell at Wendover, Bucks. One of these is being exhibited at Aylesbury, being between three and four inches long, and about six inches in circumference, weighing twenty ounces.

Institute of International Law.—The annual session of Institute is being held this year at Brussels. The meeting commenced on the 1st instant. Among the subjects for discussion is a paper by M. Louis Renault on "The International Protection of Submarine Telegraph Cables."

The Cuba Submarine Telegraph Company (Limited). —The number of messages passing over the lines of this Company during the month of August was 2,016, estimated to produce £2,300, against 2,511 messages, producing £2,569 in the corresponding month of last year. The traffic receipts for the month of June, estimated at £2,400, realised £2,425.

Results of Intemperance.—A skilled labourer, Thomas Pool, recently employed at the Postal Telegraph Works, Gloucester-road, was discharged because of increasing fondness for drink. Within ten days of his discharge he committed suicide by throwing himself in front of a train. Why will men give way to a practice which in so many cases leads to misery, if not to such a fatal result as the one we record?

A New Metal "Samarium."—According to *La Correspondance Scientifique*, M. Lecoq de Bois Caudroin has, by means of spectrum analysis, discovered the existence of a new metallic oxide, somewhat similar to "Decipium," discovered by M. Delafontaine. The earthy salts extracted from *Samarkite* constitute the source of the oxide, from which a few centigrammes of pure samarium have been obtained at the cost of four months' labour.

Telegraph Offices on the Continent.—From the most recent statistics it appears that the number of telegraph offices throughout Europe (omitting Great Britain) is 18,141, viz.:—Germany, 5,473; France, 4,188; Austria, 2,773; Italy, 1,772; Switzerland, 1,032; Belgium, 636; Russia, 523; Spain, 349; Netherlands, 283; Sweden, 249; Norway, 195; Portugal, 163; Roumania, 134; Denmark, 129; Turkey, 87; Greece, 75; Servia, 40; Luxemburg, 36; and Montenegro, 4.

Curious Effect of Lightning.—During the violent storm which recently swept over the east of France, a man named Daunois was running for shelter towards the farmhouse of Huertvent, whilst carrying a long American pitchfork over his shoulder, when he experienced a strong shock and was thrown to the ground, the fork being, as he declares, forcibly wrenched from his grasp. The implement was picked up at a distance of fifty metres from the spot where the man fell. The two prongs had been brought close together and were twisted in corkscrew fashion as regularly as though the operation had been effected by machinery. The steel was burned and fell away in scales having a slight sulphurous odour. The points of the fork had been drawn out and lengthened by several centimetres.

Antimony.—This metal, as ordinarily deposited by electrolysis, appears to be always more or less *alloyed* with hydrogen, *i.e.* a compound of antimony with hydrogen is obtained at the cathode. We have recently seen some deposits, said to be of nearly pure antimony, which differed very considerably in appearance from the metal as usually obtained; being somewhat similar to nickel. These deposits were supposed to be free from hydrogen, and were produced by means of a process which has not been made public. It was observed by Gore that, when antimony is rapidly deposited from a solution of its chloride, the compound of antimony and hydrogen thus obtained decomposes explosively when struck or rubbed with any hard substance, a small cloud of white vapour being produced, together with considerable heat and sometimes a flash of light. It has hitherto been difficult to obtain coatings of antimony strongly adherent to iron; but this desideratum is stated to have been obtained by the process above referred to, and may pave the way to a very extended application of this metal, the uses for which are at present somewhat limited.

Fatal Thunderstorm.—Among the many fatalities from lightning is the following, given by the *Journal de Génève*, describing a strange disaster which a few days ago befell the village of Valmala, situated in the valley of the same name. Besides a beautiful parish church, dating from the Middle Ages, the commune possesses the famous sanctuary of Madonna de Valmala, at this time of the year frequently visited by curious travellers, and much resorted to by the faithful of the neighbourhood. The sanctury being crowded with worshippers, at the very moment when the officiating priest was saying mass a loud peal of thunder was heard, and the building was struck by lightning which, entering by the bull's-eye over the choir, ran round the cornice, then fell on the paved floor, flashed through the principal entrance and disappeared, leaving the congregation stupefied with horror. Six people had been struck down by the fatal fluid, one of whom, a little girl, who was kneeling near her parents, was killed on tha spot, and the others are injured beyond hope of recovery. Several persons who were near the door had the soles of their shoes torn off, and four goats which had taken refuge from the storm under the porch of the sanctuary were killed where they stood.

A New Theory of the Earth's Magnetic Poles.—From a study of the movement of the compass-needle producing declination at London, Mr. B. G. Jenkins, of the Royal Astronomical Society, has become convinced that the various vicissitudes of the needle during the last 300 years can best be explained by the supposition of a strong magnetic pole above the earth's surface, and revolving around the geographic north pole in about 500 years. He finds four magnetic poles, as maintained by Halley and Handsteen, to be necessary to explain satisfactorily all the phenomena of terrestrial magnetism, but he places these not in the earth,

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but in the atmosphere. These poles he regards as the free ends of as many broad magnetic belts, two extending from the vicinity of the north pole to the equator, the other two coming up from the south pole to meet them, the boreal magnetism of the northern belts uniting with the austral magnetism of the southern belts along the magnetic equator. These bands he believes to revolve at slow and unequal rates round the poles of the earth, producing secular variations. It will be observed that Mr. Jenkins describes the magnetism of the northern hemisphere as "boreal." Contrary to the current theory, he holds that the north end of the compass needle is a true north pole, and that the facts observed are, when properly understood, in full accord with the great magnetic truth that like poles repel and unlike poles attract. After submitting the evidence in favour of this view, Mr. Jenkins argues in this wise: If the north end of the dipping needle is a south pole, its pointing to the ground in Boothia (where Sir James Ross located the earth's north magnetic pole) must be attributed to attraction. If it is attracted it is attracted by something either in the crust of the earth or at the centre of the globe. If there is something in the earth's crust which attracts the needle in Boothia, it ought to attract the needle in London. But the needle in London is attracted neither to the crust at Boothia nor to the earth's centre. The truth is, Mr. Jenkins believes, that the north pole of the needle pointed to the ground almost perpendicularly in Boothia because it was repelled by the true north magnetic pole in the atmosphere above that region when Sir James Ross was there fifty years ago. Further evidence as to the existence of the alleged magnetic belts above the earth's surface is promised. In the meantime it is of the first importance, Mr. Jenkins thinks, that it should be clearly settled whether the magnetic pole remains in or above Boothia. According to his calculations, it should now be in lat. 72 deg., long. 115 deg., in Prince Albert Land.

Singular Recovery of Sight.—A curious case of sudden blindness and subsequent restoration to sight by means of the metal cure, and above all by statical electricity, is mentioned in the *Journal des Débats* as having been communicated to the Société des Hôpitaux by MM. Dujardin-Beaumetz and Ch. Abadie. On the 22nd of January, 1878, a young girl, aged 16, a pupil of the Seine normal school, complained of a dull pain in the head. She was accordingly sent to the infirmary, went to sleep, but on waking next morning found she was perfectly blind. On examination the eye was declared normal; but M. Abadie had no trouble in discovering that the whole surface of the body had become insensible to pain. Punctures made in the forehead, on the neck, on the arms, on the legs were not felt; they did not even bleed. It seemed likely that he had to do with a case of hysterical amblyopia. The successes obtained by MM. Charcot and Dumontpallier by the application, in such cases, of pieces of metal to the parts affected, according to Dr. Burq's method, are well known in France, and three pieces of gold were applied to the region of the left temple. At the end of a quarter of an hour the young girl declared that she began to see after a confused manner; after half an hour the restoration of sight to the left eye was complete. On the right side there was no trace of the perception of light. A magnet was applied. The sight slightly improved; but at the end of ten minutes the patient felt so painful a sensation in the head that it was thought best to suspend the application of the magnet. The operation was recommenced more than once; but it was always found necessary to stop; the pains in the head became acute. During the third attempt the patient went to sleep, and fell into a lethargic state. Recourse was again had to the metallic therapeutics, experiments being made with other metals than gold, but without any very marked result. MM. Dujardin-Beaumetz and Abadie, who had shortly before read an interesting article on the cure of certain hysterical manifestations by means of statical electricity ("Progrés Medical" No. 8, 1879), resolved to make trial of that method. The patient was placed on the insulated footstool of the electrical machine, and put in communication with one of the conductors. When she was sufficiently charged with electricity sparks were drawn from the rims of the orbits; the explosion accompanying each spark called forth a pretty sharp sensation of pain. After a *séance* of a quarter of an hour her eyesight sensibly improved. The treatment was repeated every other day for a week; the clouds which had obscured her vision were dispersed; they had never returned, and the cure was pronounced complete.

A New Genus in Telephones.—The Rataphone.—Prof. A. E. Dolbear, writing to the *Journal of the Franklin Institute*, describes the kinds of telephones as the common form, the motograph form of Edison, which has but one representative, and depends upon friction for its action. The stronger the current the less the friction, and these conditions are so rendered mechanical as to effect a transformation of electrical waves into corresponding sound waves in air. The following is a description of still a third kind, as unlike either of the former as they are unlike each other. While experimenting with a common string telephone, with a screw tied to the end of the short string of three or four inches, the screw being made the armature to an electro-magnet in circuit with an Edison transmitter, Prof. Dolbear found that speech was plainly rendered when the screw adhered to the pole of the magnet, provided that the screw was slowly dragged over it when the variable current was passing. These results led to a new instrument. A short straight bar electro-magnet is furnished with a crank so that it may be rotated in its coil. Lying upon the poles of this magnet is a bent armature. The back of the armature is fastened to a plate of mica, paper, or thin iron, mounted like similar plates in ordinary receivers, so that any motion of the armature poles is imparted to the plates. Suppose a current of electricity traverses the bobbin, the straight bar becomes a magnet with strength proportionate to the strength of the current, and the armature will adhere to the poles of it with a certain degree of adhesion. Now let the crank be turned slowly, and the adhesion of the armature will result in stretching the plate, and the cessation of the current will permit the plate to regain its former position through its own elasticity. A varying current will result in varying adhesions and the consequent vibrations of the plate, and talking may plainly be heard with an instrument constructed thus. This instrument he has named the Rataphone. Of course there are many ways in which this principle may be utilised. Instead of rotating the magnet, the ends of the armature may be prolonged, and rest upon a cylinder or pulley, which may be rotated, and the varying attractions will cause the diaphragm to vibrate. If a strip of paper be put between the armature and the poles of a common relay or sounder which is in circuit with a transmitter, and the paper be slowly drawn along while an intermittent or vibrating current passes, the ear applied to the paper will hear the sounds, and articulate speech, if the current be varied by such sounds, and if the armature itself be so made as to rotate, the same effects will be produced.

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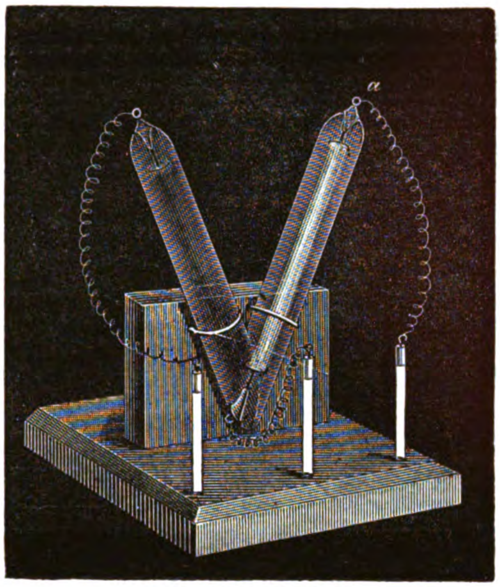
RADIANT MATTER.*

BY WILLIAM CROOKES, F.R.S.

(CONTINUED FROM PAGE 178.)

RADIANT MATTER PROCEEDS IN STRAIGHT LINES.

The Radiant Matter whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. Here is a V-shaped tube (Fig. 6), a pole being at each extremity. The

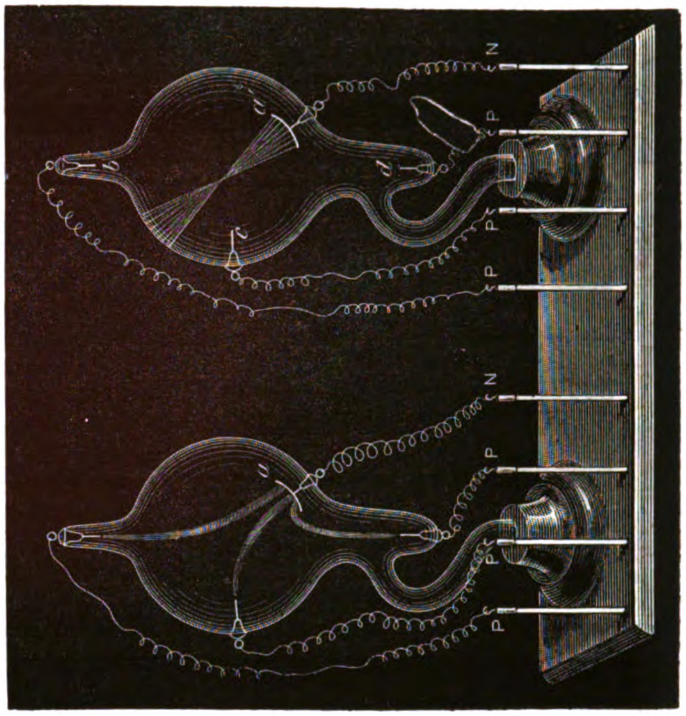


pole at the right side (a) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply and will not turn the corner to get into the left side. When I reverse the current and make the left pole negative, the green changes to the left side, always following the negative pole and leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum tubes—phenomena with which we are all familiar—it is customary, in order to bring out the striking contrasts of colour, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual gas follows all the convolutions into which skilful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaustion hitherto used to get the best phenomena of vacuum tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (Fig. 7), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—whilst the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (A) with the induction-coil, and retaining the pole at one side (a) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

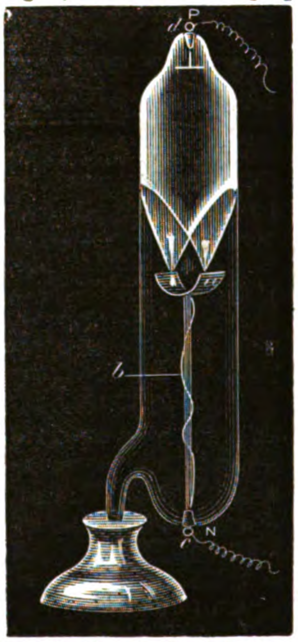
This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a bulb (B) that is very highly exhausted, and as before, will make the side pole (a') the negative, the top pole (b) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The molecular rays from the cup cross in the centre of the bulb, and thence diverging fall on the opposite side and produce a circular patch of green phosphorescent light. As I turn the bulb round, you will all be able to see the green patch on the glass. Now observe, I remove the positive wire from the top, and connect it with the side pole (c). The green patch from the divergent negative focus is there still. I now make the lowest pole (d) positive, and the green patch remains where it was at first, unchanged in position or intensity.

We have here another property of Radiant Matter. In the low vacuum the position of the positive pole is of every import-



ance, whilst in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence: the Radiant Matter darts all the same in a straight line from the negative.

If, instead of a flat disc, a hemi-cylinder is used for the negative pole, the Matter still radiates normal to its surface. The tube before you (Fig. 8) illustrates this property. It contains,



as a negative pole, a hemi-cylinder (a) of polished aluminium. This is connected with a fine copper wire, b, ending at the platinum terminal, c. At the upper end of the tube is another terminal, d. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of Matter being driven from the hemi-cylinder in a direction normal to its surface come to a focus and then diverge, tracing their path in brilliant green phospherescence on the surface of the glass.

Instead of receiving the molecular rays on the glass, I will

* A lecture delivered to the British Association for the Advancement of Science at Sheffield, August 22, 1879.

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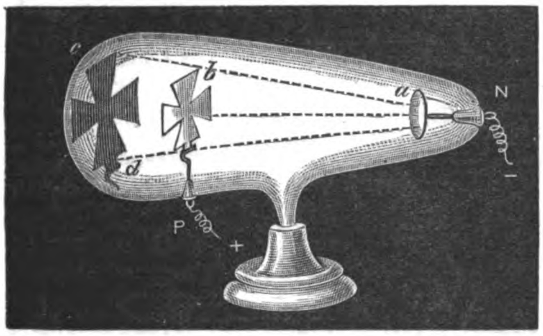
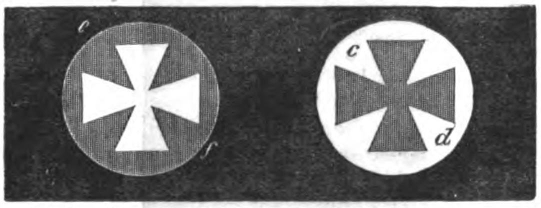
show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

RADIANT MATTER WHEN INTERCEPTED BY SOLID MATTER CASTS A SHADOW.

Radiant Matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would be the case were the exhaustion less good. Where there is nothing in the way, the rays strike the screen and produce phosphorescence. and where solid matter intervenes they are obstructed by it, and a shadow is thrown on the screen. In this pear-shaped bulb (Fig. 9) the negative pole (*a*) is at the



pointed end. In the middle is a cross (*b*) cut out of sheet aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I turn on the coil, and you will all see the black shadow of the cross on the luminous end of the bulb (*c*, *d*). Now, the Radiant Matter from the negative pole has been passing by the side of the aluminium cross to produce the shadow; the glass has been hammered and bombarded till it is appreciably warm, and at the same time another effect has been produced on the glass—its sensibility has been deadened. The glass has got tired, if I may use the expression, by the enforced phosphoresence. A change has been produced by this molecular bombardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh; therefore if I throw down this cross—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross (*c*, *d*, Fig. 10) change to a

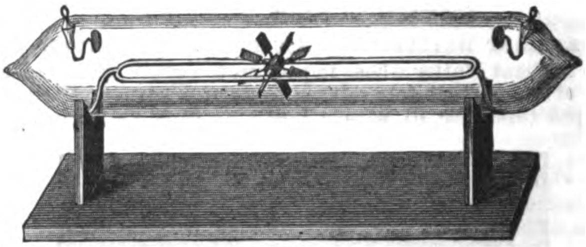


luminous one (*e*, *f*), because the background is now only capable of faintly phosphorescing, whilst the part which had the black shadow on it retains its full phosphorescent power. The stencilled image of the luminous cross unfortunately soon dies out. After a period of rest the glass partly recovers its power of phosphorescing, but it is never so good as it was at first.

Here, therefore, is another important property of Radiant Matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

RADIANT MATTER EXERTS STRONG MECHANICAL ACTION WHERE IT STRIKES.

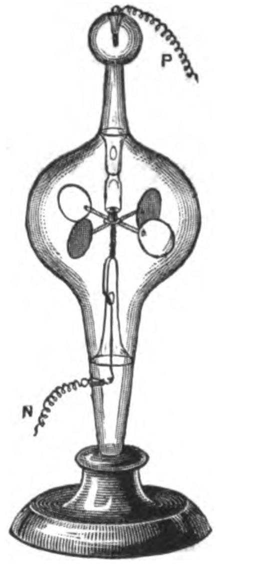
We have seen, from the sharpness of the molecular shadows, that Radiant Matter is arrested by solid matter placed in its path. If this solid body is easily moved the impact of the molecules will reveal itself in strong mechanical action. Mr. Gimingham has constructed for me an ingenious piece of apparatus which when placed in the electric lantern will render this mechanical action visible to all present. It consists of a highly-exhausted glass tube (Fig. 11), having a little glass railway running along it from one end to the other. The axle of a small wheel revolves on the rails, the spokes of the wheel carrying wide mica paddles. At each end of the tube, and rather above the centre, is an aluminium pole, so that whichever pole is made negative the stream of Radiant Matter darts from it along the tube, and striking the upper vanes of the little paddle-wheel



causes it to turn round and travel along the railway. By reversing the poles I can arrest the wheel and send it the reverse way, and if I gently incline the tube the force of impact is observed to be sufficient even to drive the wheel up-hill.

This experiment, therefore, shows that the molecular stream from the negative pole is able to move any light object in front of it.

The molecules being driven violently from the pole, there should be a recoil of the pole from the molecules, and by arranging an apparatus so as to have the negative pole movable and the body receiving the impact of the Radiant Matter fixed, this recoil can be rendered sensible. In appearance the apparatus (Fig. 12) is



not unlike an ordinary radiometer with aluminium discs for vanes, each disc coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer, therefore, can be connected with an induction-coil, the movable fly being made the negative pole.

(TO BE CONTINUED.)

BRITISH ASSOCIATION.

Mathematical Section.

Etherspheres.

The Rev. S. Earnshaw, M.A., (Sheffield), read a paper before Section A. on "Etherspheres as a *Vera Causa* of Natural Philosophy." The author of this communication, assuming an admitted parallelism between the phenomena of light and heat, proceeded by means of three hitherto overlooked propositions in natural philosophy to establish the universal existence of what he denominated etherspheres, the third of his propositions being —"Every atom of matter in the universe is surrounded by an ethersphere of its own." The following is the system of Nature which he found sufficient for his purpose. 1. In Nature there are two distinct substances, matter and ether, neither of which has any power to attract or repel the other. 2. Matter consists of atoms which attract each other with forces varying according to the Newtonian law (distance)². 3. The atoms of bodies of the same kind are alike in all respects; atoms of bodies of different kinds differ from each other in size, and possibly also in other respects, such as shape, &c. 4. Atoms, whether of matter or of ether, are incapable of experiencing any change of figure or dimensions; and they are all assumed to be of such geometrical forms as cannot fill space. 5. From the phenomena

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of light it has been inferred that atoms of ether repel each other with a force varying as (distance)[4]. 6. Every atom of matter is impervious to ether, and acts on ether in no other way than by pressure of contact. 7. A portion of space filled with matter is necessarily void of ether; and all space void of matter is pervaded by ether. 8. The enormous velocity of light in free space has led to the opinion that very great must be the repulsive power of ether on ether; and it seems to follow from this that an ether atom will experience great difficulty in moving from one part of the ethereal medium to another. Except as waves and currents, ether motion will be under great restraints, and especially shall we see this when we also remember the high power (4) of its inverse law of force. 9. In free space light is believed to be transmitted with the same velocity in every direction, and from this we infer that the atoms of ether are all spherical in form. Defining an ethersphere, the author said all space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word 'ethersphere.' If any portion of space be rendered void of ether from any cause whatever, that space has become void of the repulsive forces which were centred within it, and that, consequently, when these forces are taken away the medium outside the space will draw closer towards that space; and if the space be occupied by an atom of matter, the density of the surrounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it. This excess of ether about the vacant space above its original quantity constitutes the ethersphere; and though this gathering together of ether about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium. Mr. Earnshaw then argued that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the intersticial spaces of the body which lie between its atoms. By means of these etherspheres the author believed the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light. They were shown to have a remarkable bearing also on the phenomena of magnetism, electricity, galvanism, and the various sciences connected with the agency of imponderables. He therefore concluded that etherspheres constitute a *vera causa* the existence of which in Nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

A short discussion followed, in the course of which Mr. J. E. H. Gordon (assistant secretary of the Association) observed that if the Rev. Mr. Earnshaw could finally establish his theory, it would be a great help to all persons at present engaged in the study of electricity.

The Rev. Mr. EARNSHAW remarked that he intended to publish a portion of his paper, but the working out of his theory must be left to some younger person.

Mr. LODGE inquired if Mr. Earnshaw considered that ether has the property of inertia.

Mr. EARNSHAW replied in the negative. He did not require that it should possess that property.

Professor EVERITT asked what was the particular experimental law relating to gases which followed from his theory?

Mr. EARNSHAW replied that, speaking roughly, one was that there was a pressure, whatever might be the nature of the gas, and of course the pressure depended upon the elasticity of the gas. The inter-penetration of gases was dependent upon the fact that the sizes of the particles of the two gases differed. That caused their etherspheres to vary in size, and thus enabled one gas to penetrate to the other.

ON LIGHTNING PROTECTORS FOR TELEGRAPHIC APPARATUS.*

By WILLIAM HENRY PREECE, Electrician, General Post Office.

For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity, because the damage done was so insignificant, and because the remedy was found to be worse than the disease.

But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried, based on the fact that, when a discharge takes place through a non-conductor, such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and, therefore, all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles" ("Researches," Series XII., p. 1406). Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line is placed above it, but separated from it by paper or by insulating washers. The lightning, on entering the wire, bursts across the paper or air space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool, the opposing faces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy by Mr. C. V. Walker, F.R.S.

Messrs. Siemens' arrangement, very pretty in theory, never carried conviction of its value in the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared; and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of point that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate protectors, identical in dimensions, excepting that two were serrated and two were not. The two plates were separated from each other by narrow ebonite washers ·01 inch thick. The upper plate was placed in connection with the positive pole and the lower plate with the negative pole. The number of cells were increased until a continuous current of electricity flowed.

1.—PLAIN PLATES.

No. of Cells.	Effect produced.
1,000	Slight sparks just commencing on completing circuit.
1,080	Sparks evident.
1,200	Sparks frequent and abundant.
1,500	Continuous arc.

2.—SERRATED PLATES.

No. of Cells.	Effect produced.
1,000	Sparks just commencing on making contact.
1,080	Sparks evident.
1,200	Sparks frequent.
1,500	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character.

Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Muller on the striking distance between two flat discs, given by them in their Paper read before the Royal Society (*Phil. Trans.*, Vol. I., pp. 69—77), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 cells struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post Office Telegraph Department to keep these plates apart by thin paraffined paper ·002 inch thick, so that the air space is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs. De la Rue and Müller have shown that, for points and various kinds of surfaces opposed to each other, plane surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now, as it is doubtful whether atmospheric electricity causes much higher potential in telegraph wires than 1,000 volts, it is clear that plane surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren de la Rue for the performance of the experiments in his laboratory.

* A Paper read before Section A at the late meeting of the British Association at Sheffield.

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THE ELECTRIC LIGHT IN LIGHTHOUSES.

During the last session of the Institution of Civil Engineers the question of the application of the Electric Light to Lighthouses was discussed at great length. Mr. J. N. Douglass, the Engineer of the Trinity House, commenced the discussion with a paper which practically exhausts the historical development of the electric light in this direction, besides giving a vast amount of other information. The paper, with an abstract of the discussion, has since been published in the proceedings of the Institute, and with Mr. Chance's paper on "Dioptric Apparatus in Lighthouses for the Electric Light" makes the number a very interesting and important one to all electricians. From these sources we obtain most of the information now given. The great desideratum in a lighthouse luminary would appear to be a maximum intensity, combined with perfect focussing compactness in the optical apparatus for condensing the radiant light into an intensified beam, and directing it to the sea surface for the guidance of the sailor. The ancient beacon-fire could hardly be said to comply with any of these requirements, and until late in last century the luminaries were generally wood or coal fires. In 1696 tallow candles were adopted, in 1763 oil lamps, in 1823 coal gas was proposed, in 1837 the Bude light was tried, in 1862 the lime light, but previous to this, viz., in 1858, the electric light was first shown at sea from the South Foreland high lighthouse. The discoveries of Faraday had been applied by Pixii, Clarke, Caxton, and later on by Nollet, whose work induced Holmes to take up the question, the result being a magneto-electric machine powerful enough to produce the electric light of sufficient intensity for lighthouse illumination. A valuable consideration for the use of the electric light is that, owing to its small dimensions, it is practicable to avoid the waxing and waning appearance of the flashes of an oil or gas light, so that the flashes appear and disappear suddenly, are of nearly uniform intensity throughout, and no appreciable variation occurs in the intensity of each succeeding flash. The smallness of the source of light, again, renders it possible to utilise more of the light, and brings the optical apparatus employed into closer alliance with that generally described in text-books. It is well known that the student of optics generally commences his labours with studying the effects of light from a focal point, or rays from an infinite distance, which are supposed to be perfectly parallel. We may digress for an instant to mention that an ordinary tumbler nearly full of milk will, by the aid of a candle, give an exceedingly good illustration of a caustic curve. This apparatus is simple and within the reach of every student. To resume, it will at once be seen that, compared with coal-fire, tallow-candles, oil or gas lamps, the source of light with the electric arc approaches much more closely to a point than either of the others.

At Souter Point, for the first time, the rear light of the luminary was utilised by Mr. Chance designing, at the suggestion of Mr. Douglass, an optical apparatus which reflects a large portion of this part of the light, at first vertically downwards, then through a window in the tower twenty-two feet below the apparatus, for the special purpose of marking certain dangers in Sunderland bay. Thus the one source guards against two dangers. The installation of the electric light also assists in providing against another danger. It is well known that light at times cannot penetrate through long distances of peculiarly constituted atmosphere, hence whistles, bells, fog-horns, guns, sirens, and other contrivances for warning the sailor of hidden dangers. According to Professor Tyndall's experiments, the best of all these is the siren, which however necessitates the use of steam power. The motive power for a first-class fog signal is sufficient for the production of an electric light at the focus of the optical apparatus, with an intensity of about 25,000 candles.

The above and other reasons all point to the extensive use of electricity as a lighthouse luminant, and we believe the new Eddystone lighthouse will be furnished with this light and an optical apparatus of the first order. The question of expense ought in lighthouse work to be to a certain extent subsidiary to efficiency. The saving of one ship with its human freight cannot be estimated by pounds, shillings, and pence; but even if these constituted the sole question to be decided the adoption of the electric light would be compulsory. The appendices to Mr. Douglass's paper are conclusive

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on this point. In these tables he gives the first cost, annual cost, cost per hour, &c.; he compares the electric light with oils and gas as to luminosity, &c., and in each case the electric light shows its superiority. Since its first introduction there has been a very great diminution as to cost, and as great an increase in its efficiency. Thus, taking Dungeness (one light), Souter Point (one light), South Foreland (two lights), and Lizard (two lights), the cost is respectively as the following numbers—100, 43·6, 32·9, 11·4; the total light per annum in candles is respectively as 100, 264, 528, 1,306, the mean intensity in candles of the luminary at the focus of the optical apparatus for 365 nights, or 4,412 hours, is respectively as 670, 1,768, 3,536, and 8,751. The following are the results obtained as to the cost per hour of a single light (shore station, (i) without siren fog signal, (ii) with siren fog signal, with *Colza oil* (α. old Fresnel system) (β New Trinity House system) *mineral oil; Wingham's gas system* (α. six-wick) (β Haisboro') (γ Gatley Head intensity). *Electricity* (α. one Lizard) (β two Lizard intensity) respectively as:—

(*i*) 100, 74·8, 65·0, 76·2, 30·1, 22·4, 13·3, and 6·3

(*ii*) 100, 100, 100, 74·94, 74·94, 74·94, 52·22 and 32·01

showing, as we say, the superiority of the electric light as the source of luminosity in every case.

This whole question is one of supreme importance to all maritime countries, and it is to their advantage that all lighthouses should be served in the best possible manner. In many cases natural sources of motive power could be utilised, with a corresponding gain as to expense. We trust the information now to be so easily obtained on the subject will be carefully studied.

THE SPECIFIC INDUCTIVITY OF GLASS.

On Secular Changes in the Specific Inductive Capacity of Glass.*

BY J. E. H. GORDON, B.A., ASSISTANT SECRETARY OF THE BRITISH ASSOCIATION.

At Christmas, 1877, I made some determinations of the specific inductive capacity of optical glass by a method which has already been fully described both before this section and elsewhere.†

At the end of July, 1879, I commenced a repetition of the experiments, using the same slabs of glass, and was surprised to find a large increase in the specific inductive capacity in every case. In some cases the increase was as much as 20 per cent.

The following is a table of the results:—

Specific Inductive Capacity of Optical Glass.

—	Christmas, 1877.	July and August, 1879.
Double extra dense flint	3·164	3·838
Extra dense flint	3·053	3·621
Light flint	3·013	3·443
Hard crown	3·108	3·310

The arrangement of the apparatus, including the coil and rapid break, was precisely the same as in my earlier experiments. The electromotive force was as nearly as possible the same, and experiment has shown that moderate variations in it do not affect the results.

The differences observed might have been caused by any one of three things:—

1. By error in the 1879 experiments.
2. By error in the 1877 experiments.

* Paper read before Section A of the British Association at Sheffield.

† "Report Brit. Assoc., 1879;" "Proc. Roy. Soc., 191, 1878;" "Phil. Trans., 1879;" "Four Lectures on Electric Induction," delivered at the Royal Institution (Sampson Low and Co.), 1879.

3. By a change in the specific inductive capacity of the glass between Christmas, 1877, and July, 1879.

Careful repetition of the 1877 experiments have convinced me that there is no error in them.

If the difference is caused by error in the 1877 experiments, then in 1877 I must have obtained too low a result. With my induction balance the effect of covering the dielectric with a well-conducting film is to prevent observation; the effect of covering it with a badly-conducting film is to give too low a result.

Before rejecting the second explanation of the difference, based on the hypothesis of error in the 1877 experiments, it is, therefore, necessary to prove that in 1877 there was no film on the surface of the glass of sufficient conducting power to cause a large error in the results.

In 1877 the glasses were not washed by immersion in water, but were thoroughly cleaned with a glass cloth and wash-leather. To the best of my recollection they were first rubbed with a damp cloth, then with a dry one, and then polished with the leather, being frequently breathed on during the process, and then usually warmed at the fire. This process was so efficacious in removing any conducting film of moisture from the glasses, that at the end of it they were usually found to be electrified by the friction of the leather. When this occurred they were passed rapidly a few times over the flame of a spirit lamp to discharge them. They were always so warm that any visible moisture deposited by the spirit lamp disappeared instantly.

In the 1879 experiments, which are quoted in the preceding table, the glasses were washed in hot water, wiped and polished, and passed over the spirit lamp while still hot. After observing a difference in the first two specimens examined, I made preliminary experiments on the other two before cleaning them. The following are the results obtained:—

Hard Crown Glass.

	S.I.C.
Christmas, 1877	3·108
August 7, 1879.—Not wiped for more than a year; placed in balance covered with dust exactly as taken from box, which does not shut air-tight	3·236
August 8.—Cleaned in hot water as described above	3·310

Light Flint Glass.

Christmas, 1877	3·01
August 4, 1879.—Dusted lightly with duster, not rubbed	2·90
August 4.—Cleaned in hot water, experimented on while hot	3·44
August 4.—Cooled under tap, wiped with glass-cloth	3·44
August 5.—Had stood twenty-four hours uncovered on table, not wiped	3·39
August 5.—Smeared all over with oil	3·48
August 5.—Smoked on oily surface over paraffine lamp, so as to make glass semi-opaque	3·46
August 5.—Glass made very wet with solution of sal-ammoniac	Experiment impossible.
August 5.—Roughly dried with duster; surface appeared opaque, like ground glass	1·64
August 5.—Wiped over with glass-cloth, but not rubbed	2·36
August 5.—Rinsed under cold tap, and wiped with glass-cloth, but not polished	3·46
August 5.—While still cold, passed over spirit-lamp till much more clouded than ever would be the case in actual work; placed in balance, and experiment made as quickly as possible	3·48

My conclusion from the above numbers is that although it is possible by sufficiently wetting the surface of the plate to produce any apparent reduction of the specific inductive capacity, yet that even if very much less care had been taken to clean the plates than was taken in 1877, the greatest quantity of moisture that could accidentally have been left on them would have been totally incapable of producing anything like the difference now under examination.

I am, therefore, led to the conclusion that in the course of a year and a half an actual change has taken place in the glasses, which is shown by a considerable real increase in their specific inductive capacities. To complete our knowledge of this new phenomenon we require a series of monthly observations, extended over perhaps a period of several years. I shall hope to be able to give the results of another year's experiments at the next meeting of the Association.

These experiments have some importance as regards Professor Clerk Maxwell's electro-magnetic theory of light. In a recent

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lecture I ventured to suggest "that it is quite possible that the relation between electric induction and light exists, namely, that they are disturbances of the same ether, but that there is some unknown disturbing cause affecting the electric induction."

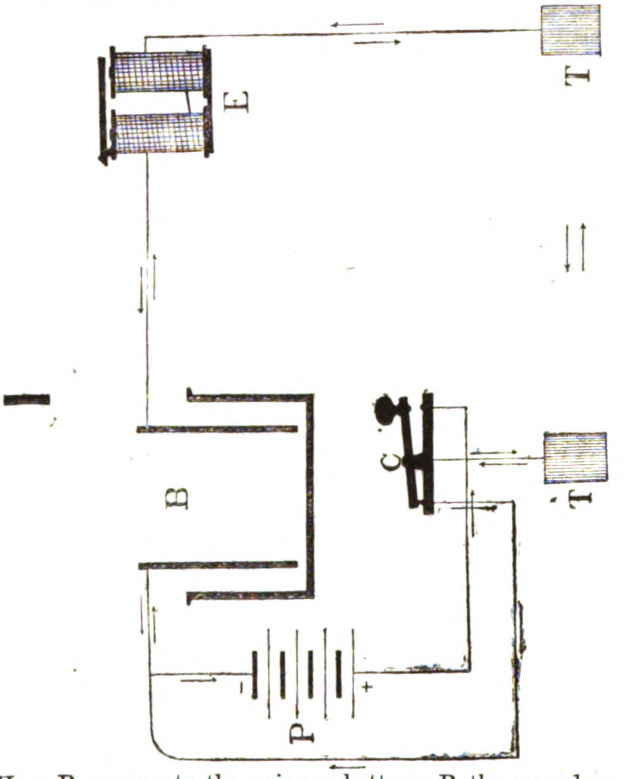
Possibly a clue to the nature of this disturbing cause may be found in the fact that the specific inductive capacities are affected by some of the changes which chemists tell us are constantly going on in glasses, but that these changes do not affect the refractive indices.

NOTES OF MR. WILLOUGHBY SMITH'S PAPER ON "THE WORKING OF LONG SUBMARINE CABLES."

I.

The Counter-current System of Jacobi for the Transmission of Electrical Signals.

One of the many subjects of interest, both historically and from the point of view of the student of electrical science, referred to by Mr. Willoughby Smith in his important paper read before the Society of Telegraph Engineers, on February 12, 1879, was the method of employing a secondary battery to give sharpness to the signals obtained by means of an electro-magnet. The connections for carrying this into effect are represented in the following diagram :—

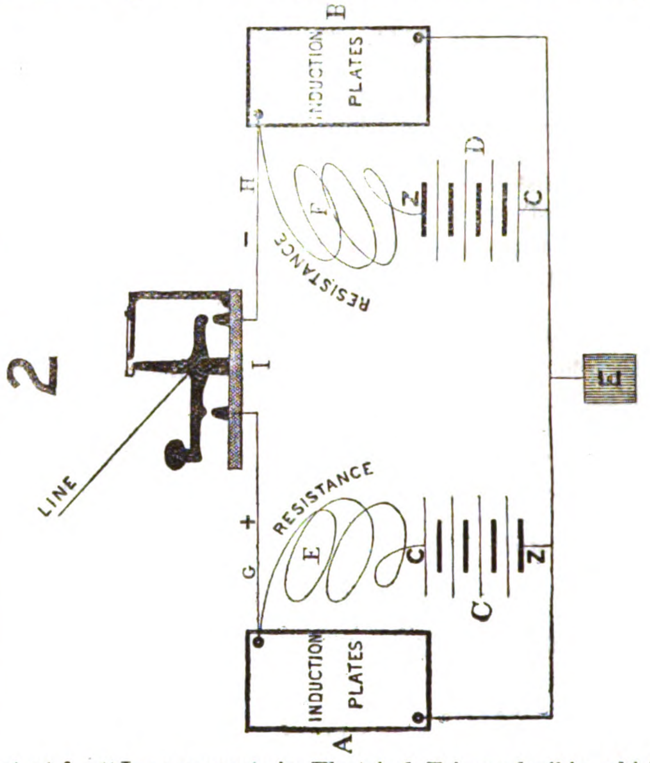


Here P represents the primary battery, B the secondary or polarisation battery, which, as employed by Prof. Jacobi, consisted of plates of platinum immersed in dilute sulphuric acid, C is the (Morse) key for transmission, and E is the receiving electro-magnet. When the key is depressed, a current from the primary battery passes in the direction indicated by the lower arrow between the earth plates T T, traversing the electro-magnet and the secondary battery, of which the right-hand plate becomes "polarised" by oxygen, and the left-hand plate by hydrogen, and completes the circuit to the negative pole of the primary battery. The platinum plate, which is "polarised" or *electro-coated* with hydrogen, constitutes the positive element, or negative pole, of the secondary couple, which, it will be seen, is thus opposed to the primary battery. When the key is allowed to return to the position shown, a reversal current is given by the secondary battery. The object of Prof. Jacobi in applying this device to telegraph lines was to remove from the electro-magnet the residual magnetism, which has a tendency to retard signalling by holding down the armature of the electro-magnet after the signalling current has ceased. Or, in the words of Mr. W. Smith, "to overcome what he termed 'the injurious effects of condensed magnetism,' he introduced a polarisation battery into the circuit, so that, 'if the electro-magnet has preserved its attractive action, the latter finds itself destroyed by the secondary current; and as the polarisation current varies in intensity with the current of the working battery, the system being once properly adjusted, the injurious effects of the condensed and residual magnetism are always counteracted by a force which increases or diminishes with them.'"

The same result has been obtained by means of two opposed primary batteries, of which one is considerably stronger than the other. It is questionable whether these devices offer any advantage that cannot be obtained by the use of a reversal key.

II.

A reversal key, and the mode in which its front and back stops are connected to the opposite poles of a battery of which the middle portion is brought into contact with earth, are represented in Fig. 2. This diagram illustrates Mr. C. F. Varley's



patent for "Improvements in Electrical Telegraphs," in which the use of condensers, or induction-plates as a substitute for the same, is for the first time claimed. At the date of this patent, electricians, probably without exception, were labouring under the erroneous impression that electromotors of enormous power were necessary in order to transmit a signal with rapidity through a long submarine cable. Mr. Latimer Clark's experiment of sending signals through such a cable by means of a battery formed of a gun-cap and a minute fragment of zinc had not been tried, and would have been considered an impossibility; and the ideas of sending successive *waves* of electricity through a long cable had not yet taken form. The object of the resistances E and F was, therefore, to safeguard the cable against the direct action of the powerful batteries or induction coils proposed as electromotors. Making due allowance for the false notion adverted to, we cannot fail to recognise the ingenuity of the means proposed and the value of the device for preventing in some measure the sudden fall or, rather, absolute disappearance of tension, which temporarily occurs when the poles of an electromotor (of any appreciable resistance) is connected in circuit with a conductor, such as a submarine cable, having a high capacity for charge. And, on theoretical grounds, we cannot help thinking that this device may, even at the present time, be advantageously utilised.

(TO BE CONTINUED.)

ON THE RETARDATION OF PHASE OF VIBRATIONS TRANSMITTED BY THE TELEPHONE.*

BY PROFESSOR SYLVANUS P. THOMPSON.

It was predicted from theoretical considerations by Dubois-Raymond that a difference of phase, amounting to a quarter of a complete vibration, would be found to exist between the

* A Paper read before Section A, British Association.

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diaphragms of two associated Bell telephones, the receiving telephone being a quarter of a vibration behind the transmitter. A more complete theory, worked out independently by Helmholtz and Weber, gave a somewhat contradictory result, and required only a small difference of phase. Recently König, in a series of delicate experiments, effected an optical comparison by the Method of Lissajous of the vibrations of a pair of telephones, replacing the vibrating discs by tuning-forks armed with mirrors. The experiment is a delicate one, and is performed under conditions not free from objection. The author has proposed the following method of observing. A pair of Bell telephones are suspended by wires of about a metre in length, so as to oscillate as pendulums, to frames so disposed as to avoid the possibility of any mechanical transmission of the vibrations. Below the point of rest of each telephone, and at some little distance from it in the plane of its swinging, is placed a steel magnet. After the lengths of the wires have been so adjusted that the telephones will swing in identical periods, one telephone is set swinging. As it alternately approaches and recedes from the magnet, the induced currents traversing the second telephone set it swinging. In every case the difference of phase observed amounted to one quarter.

In the case of those telephones which transmit vibrations by varying the resistance of the circuit, instead of varying the electromotive force, there is no such retardation of phase produced in the ordinary electro-magnetic receiver. If, however, the current so transmitted is first passed through an induction coil, a retardation of phase of one quarter is produced, and in the case of several successive inductions the retardation amounts to an additional quarter for every additional induction. This remark applies only to vibrations of harmonic and quasi-harmonic type. Vowel sounds, which consist of compound harmonic vibrations, are unchanged to the perception of the single ear, which is unable to distinguish differences of phase, or between compound sounds which differ from one another only in the difference of phase of their components. The vibrations of consonantal sounds, on the contrary, depart more and more widely from their original type at each successive induction.

In the case of Edison's motographic or electro-chemical receiver, the velocities, not the displacement of the disc, are proportional to the strength of the currents received. Hence vibrations already retarded one quarter in transmission, as is the case with those of the carbon transmitter in conjunction with its induction coil, always used with this instrument, are restored to their primitive phase. The vibrations of this receiver, therefore, agree in type, not with the vibrations of the induction current (which correspond to the derived function of those of the original vibration), but with those corresponding to the function of which the vibrations of the induction current are the derivate; that is to say, they agree in type with the primitive vibrations of whatever form. Hence, in the receiving telephone of Edison consonantal sounds which depart widely from the purely harmonic type are better rendered than in a telephone which, like that of Bell, both retards the vibrations in phase and alters them in type..

NEW MARSEILLES AND ALGIERS CABLE.

The s.s. Dacia, Captain Harward, belonging to the India Rubber, Gutta Percha, and Telegraph Works Company, sailed on Thursday from Greenhithe for the Mediterranean to lay a cable for the French Government between Marseilles and Algiers. The expedition is in charge of Mr. Robert K. Gray, engineer-in-chief of the Company, and Mr. March Webb is electrician. The shore end will be laid at Algiers first, and then soundings will be taken across to Marseilles, and the cable then laid from Marseilles to the buoy on the Algiers end. The ship will have as consort the French Government Telegraph steamer La Charente. The Dacia has all the latest improvements, including two electric lights, Sir W. Thomson's sounding machine, and buoys with gas light lamps. M. Richard, of the French Government, assisted by two electricians, inspected the cable during manufacture, and M. Winchendorf will accompany the expedition on the part of the French Government. The cable, about 520 miles in length, is in excellent electrical condition, and is to be laid about 10 miles to the eastward of the present cable. The present cable has a traffic of about 550 messages a day, sometimes reaching to 850. It was laid by the same company for the French Government in 1871. Mr. W. H. Preece and Mr. Winter, of the Postal Telegraph, and Colonel Crossman, of the War Office, accompany the ship, by invitation, to the Mediterranean, and Count Wimpfnen joins her there.

STUDENTS' COLUMNS.

DIMENSIONS AND ELECTRICAL PROPERTIES OF WIRES.*

BY W. KINGSLAND.

Most practical works on electricity contain tables of the various dimensions and properties of wires, but it is of great importance to the student to have a handy set of formulæ by which he can make these calculations for himself, and also that he should understand the derivation of these formulæ.

In considering the dimensions of a wire apart from its electrical properties, we have before us three factors—weight, length, and diameter, for each of which it is necessary to choose a unit. The units here made use of are: the grain, foot, and mil. (the mil = $\frac{1}{1000}$ inch).

If we double the length of any wire, we evidently double the weight, and we may, therefore, say that W varies as l, other things being equal. If, however, we double the diameter, we *quadruple* the weight, because the area of a circle—that is, the area of the section of our wire, varies as the square of the diameter. With this knowledge we may construct an abstract formula for the weight of a wire, viz.: $W = l\,d^2$.

To make this a concrete formula, however, we must have a constant, and this constant will evidently be the weight of a unit wire—that is, of a wire 1 foot long, and 1 mil in diameter (1 mil-foot) of the particular metal with which we are dealing.

The most convenient constant is the weight of a mil.-foot of water, because by multiplying this by the specific gravity of any other substance we obtain the weight of a mil-foot of that substance.

The weight of a cubic inch of water (at maximum density) is 252·456 grains, and this multiplied by 12 and by ·7854 gives us the weight of a circular inch-foot of water, which is 2379·3 grains. To reduce this to a mil.-foot, we must divide by the square of the diameter—that is, 1000 × 1000, which gives us ·0023793. (The multiplier ·7854 is the ratio between the areas of a square and of a circle having a diameter equal to a side of the square, and enables us, as it were, to cut off the corners of the cube, converting it into a cylinder.)

We may now calculate the weight of any wire of any metal from the following formula:

$$W = l\,d^2\,\text{Sp.G.}\cdot 0023793. \quad . \quad . \quad . \quad . \quad (1)$$

This formula, however, is too tedious for general use, and it will be found more convenient, instead of multiplying by Sp.G. ·0023793, to divide by its reciprocal, $\frac{1}{\text{Sp.G.}\ \cdot 0023793}$. We shall thus obtain the following formulæ:

$$W = \frac{l\,d^2}{k}. \quad . \ (2); \quad l = \frac{W\,k}{d^2}. \quad . \ (3); \quad d = \sqrt{\frac{W\,k}{l}}. \quad . \ (4),$$

where k is a constant to be determined for any particular metal by taking the reciprocal of ·0023793 × Sp.G. Thus the specific gravity of copper is 8·92 and $\frac{1}{8{\cdot}92 \times \cdot 0023793} = 47{\cdot}11$. We thus obtain:

Constant k for	Copper	47·11
Ditto	Iron	53· 6
Ditto	Platinum	19·52
Ditto	German Silver	48·31

This constant is the same in each equation for any particular metal.

In a similar manner the student may obtain constants for any other metals used in the manufacture of wire.

We have now to consider the resistance which a wire of any given dimensions will offer to the passage of a current.

We find by experiment that the resistance increases directly as the length. If we double the length we also double the resistance. We also find that it increases inversely as the square of the diameter—that is, if we double the diameter we diminish the resistance fourfold. We also find that every metal has a certain specific resistance *(r)*, and putting these facts together, we obtain an abstract formula for the resistance of a wire $R = r\frac{l}{d^2}$.

Here again we require a constant to make the formula arithmetically correct. This will be the resistance of a unit wire, whose specific resistance is also unity; and, as copper may conveniently be taken as unity, it will be the resistance of a mil.-foot of pure annealed copper at 32°F. This is found by experi-

* Notes of a Lecture given by Mr. D. G. FitzGerald, M.S.Tel.E., at the School of Telegraphy, George-street, Hanover-square. With some additions by the Writer.

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ment to be 9·718 ohms, and we shall thus have a formula for the resistance of any wire :

$$R = r\frac{l}{d^2}9{\cdot}718. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

In some tables silver is taken as the unit of specific resistance, and, if this is the case, the constant will be the resistance in ohms of unit silver wire (annealed), viz., 9·151, whilst the sp. resis. of copper will be 1·073.

We may, by multiplying r, the specific resistance of any metal, by 9·718, obtain a new series of constants for particular metals, and also express our formulæ thus :

$$R = \frac{lk'}{d^2}. \ . \ (6); \ l = \frac{R\,d^2}{k'}. \ . \ (7); \ d = \sqrt{\frac{l\,k'}{R}}. \ . \ (8),$$

where k' is the resistance of a unit wire of any particular metal, and is :

Constant k' for	Copper	9·718
Ditto	Iron	59· 10
Ditto	Platinum	55· 09
Ditto	German Silver......	127· 32

We now require an equation in which W shall enter as a factor, and in introducing W we may eliminate either l or d. By substituting in formula (6) our value for l in formula (3) we obtain

$$R = \frac{W\,k}{d^2} \times \frac{k'}{d^2} = \frac{W\,k\,k'}{d^4},$$

and by multiplying k and k' together, we obtain a new constant and a new set of formulæ, thus :

$$R = \frac{W\,k''}{d^4}. \ . \ (9); \ W = \frac{R\,d^4}{k''}. \ . \ (10); \ d = \sqrt[4]{\frac{W\,k''}{R}}. \ . \ (11),$$

where the constant k'' is obtained for any particular metal by multiplying together the constants for that metal in equations (3) and (6), and is :

Constant k'' for	Copper	457·88
Ditto	Iron	3168· 2
Ditto	German Silver......	6150· 6
Ditto	Platinum	1075· 4

In a similar manner we may substitute for d^2 its value according to equation (4), and thus obtain :

$$R = \frac{l\,k'}{\frac{W\,k}{l}} = \frac{l^2\,k'}{W\,k}.$$

By dividing k' by k for any particular metal we obtain a new constant and a new set of formulæ

$$R = \frac{l^2\,k'''}{W}. \ . \ (12); \ l = \sqrt{\frac{R\,W}{k'''}}. \ . \ (13); \ W = \frac{l^2\,k'''}{R}. \ . \ (14).$$

Constant k''' for	Copper	·2062
Ditto	Iron......................	1· 102
Ditto	German Silver (best quality)	2· 635
Ditto	Platinum	2· 822

It must be remembered that these formulæ give the resistance at 32° Fahrenheit, and the answer obtained must be corrected for any other temperature. They are also for pure metals whose conductivity is 100 per cent., and as the resistance of commercial metals is generally much higher, it is necessary, where accuracy is of importance, to know the percentage of conductivity in any particular case.

BRITISH ASSOCIATION.

ELECTRICITY AS A MOTIVE POWER.*

(CONTINUED FROM PAGE 180.)

No great advance can be made then in a heat engine, except by making the temperature of the working substance, steam, gas, or whatever it may be, much higher. If, for example, we could raise the temperature of the working substance as high as, say, 3,000°F., the temperature of combustion, and could make it leave the engine without artificial cooling at the ordinary temperature of the air, which is, say, 60°F. then a perfect heat engine, under these conditions, would only waste about 1-7th of the total energy ; consequently, assuming that we could, at these high temperatures, make a practical engine as good relatively to an ideal perfect engine, as we can at lower temperatures, then a practical engine would only waste 7-45ths of the total energy, or would have an efficiency of about 0·84.

But, with our present knowledge, to work with steam or gas at a temperature of 3,000° F. is almost as ideal as an engine with no friction, and with no loss of heat by conduction and radiation. We are, therefore, led to the conviction that as it is solely by working with steam at very high temperatures, that the efficiency of steam engines can be seriously increased, it may be well to consider whether it is not possible to economically replace the steam engine by some other form of motor.

In order to estimate the efficiency of electric engines, we must consider the discovery made by Faraday, to which I have referred. We know that motion can produce electricity with the ordinary glass electrical machine, and that the electricity so produced can in its turn set up motion, as in the pith ball telegraph worked by Sir Francis Ronalds. We know that difference of temperature can produce an electric current, and the electric current can in its turn produce heat, or difference of temperature. Consequently Faraday felt sure that, since an electric current can, as you have seen, produce a magnet, a magnet must, in some way, be able to create an electric current. But his attempts were baffled time after time ; failure only was the result, yet buoyed up with hope, still persevering with that dogged earnestness which is the characteristic of an Englishman, he at length arrived at this all important discovery—to produce a current with a magnet it is no use placing the magnet this way or that way relatively to the coil, but you must have *motion* of the one relatively to the other. And this coil of wire before you is the very one made by Faraday's own hands, and which he used in investigating this problem. The results obtained with it were insignificant in magnitude, but they form the foundation of all the electric lighting of the present day, and of the future electric transmission of power.

To enable you to better understand the discovery of "magneto-electric induction," I have here a coil of wire in which a magnet is suspended, and free to move in a vertical plane. Attached to the magnet is a pointer, to enable you to detect any motion of the magnet. Those of you who are near will see the pointer itself, while those who are at the other end of the room will see it projected on to the screen as a huge vertical black bar. The exact construction of this instrument is also shown in the large diagram.

Now, we know from our previous experiments that this arrangement will detect whether an electric current is flowing through the wire and also which way it is flowing ; in fact the instrument is in principle exactly the same as the one I previously used, only, as the wire goes many times round the magnet in this second instrument, it will detect a much weaker current. To the two ends of the wire forming the current-detector are attached the two ends of the wire forming this coil. The pointer of the detector is now vertical, indicating that no current is passing ; but if I rapidly move this magnet towards the coil, the pointer deflects to the left, and then comes back again to the zero position, indicating that an instantaneous electric current was set up in one direction. Now, if I rapidly remove the magnet I have in my hand, you observe the pointer makes a swing towards the right, indicating an instantaneous electric current in the opposite direction. To be quite sure that the deflections you saw produced in the suspended magnet are the results of electric currents, and are not produced by the direct attraction of the large magnet, I hold in my hand, on the suspended magnet, I make a break in the circuit of the wire so that electric currents cannot now flow ; and you observe that the motions of the big magnet produce no effect whatever on the little one at this distance.

Now, we have seen that an electric current can do work, and the principle of the conservation of energy tells us that work connot come out of nothing, therefore my hand, in moving the magnet, must do as much work as is performed by the current. As this current is weak it would be a little difficult to measure, in a simple way, the work done by my hand ; but if we take a machine for producing strong magneto electric currents, a machine called the "magneto," or "dynamo electric machine," then, as long as the wire is incomplete so that no current can flow, you see it is quite easy for me to turn the handle, but the moment a small piece of wire is inserted so that a current is induced, my hand is arrested—I can hardly turn the handle—I have to do work, hard work, in order to continue the motion of the machine, and that work has its equivalent in the electric current that flows, and in the heat which you see the current is producing in the piece of wire we inserted, and which has now become white hot.

But, perhaps you may say, although this is very interesting in connection with the mechanical production of electric currents, what has it to do with the comparison of steam engines with electro-motors, the object of which is not to produce currents, but work? The answer is, because every electro-motor, every instrument that is worked by an electric current, is also a magneto electric machine, that is, can produce electric currents, and, in addition, always is producing electric currents when it is itself set in motion by one. For taking this simple form of electro-motor—where an iron armature is attracted by an electro-magnet—this attraction arises from the fact that as soon as the current is started, the iron armature is first converted by induction into a magnet before it is attracted ; consequently when it moves up to the electro-magnet, we have the case of a magnet approaching a complete coil of wire, the result of which you now know is the production of an electric current. Now, this electric current must be in the opposite direction to the original current producing the motion, for otherwise the original current would be increased by the induced currents, therefore the armature would be pulled with more force, and the total work done by the original currents would be increased without any equivalent consumption of energy elsewhere. This induced current therefore, like all currents induced by the motion of magnets, relatively to coils of wire, *tends to stop the motion*, and must be taken into account in calculating the efficiency of an electro-motor ; in fact not only must be taken into account, but experiment shows us that it is this tendency of the electro-motor to send a back current that makes it an electro-motor at all.

This reverse current may be thus shown experimentally. I have here a battery sending a current through a Froment's electro-motor, which, as you see, can work either this pump, or this pile-driver. Now, the strength of the current, as measured by this galvanometer, is 40° when I hold the electro-motor at rest, so that it can do no work, and 30° when I allow the motor to move rapidly as you now see it doing.

When an electro-motor is worked by a *given* galvanic battery, then calculations lead us to the result that if we wish to produce the work *most economically* we must, by diminishing the load on the motor, allow its speed to increase until the reverse current it produces is only a little smaller than that sent by the battery ; in fact, until the current circulating through the arrangement is very small, in which case the efficiency of the engine, or the ratio of the work it produces in a given time to the maximum work it could produce from the same consumption of material, is

* A Discourse delivered to the Working Men of Sheffield, August 23rd, 1879, by Prof. W. E. Ayrton.

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nearly unity. If, on the other hand, we desire a *given* battery to cause the motor to do work *most quickly*, independently of the consumption of material, then calculation tells us that we ought to put such a load on the motor that its speed will send a reverse current equal to something like a half of the strength of the current the battery could send through the motor when at rest. In this case the efficiency is about ½, or half the energy is wasted in heat.

The difference between these two considerations of maximum values must carefully be borne in mind, especially as it is usually the second—or how to obtain work *most quickly*—that has generally been taken into account, whereas, this evening, it is the other one—or how to transmit work *most economically*—that will specially engage our attention.

Now, let us consider that we work our motor in the most efficient way—that is very fast with a small load, and let us consider that by so doing the efficiency is so little short of unity that we may regard it as one, then since an electro-motor worked by a battery in which zinc is burnt is 150 times as dear as a steam engine for equal efficiencies, the best electro-motor worked by such a battery will be thirty-three times as dear as our best steam engines having an efficiency of 2-9ths. We may, therefore, throw on one side at once all idea of electro-motors worked by ordinary batteries, even although the electro-motors be perfect. Now, this result is most important, since it shows, not that an electro-motor as a machine is inefficient, but that attempting to drive it with a galvanic battery is the hopelessly inefficient part of the arrangement.

But if we turn to the question of using electro-motors for the transference of power, then there is no difficulty about burning zinc, and the high efficiency of such motors is all important.

For in the case of natural sources of power, such as waterfalls, we have merely to consider what amount of energy will be produced at the distant factory; will it be sufficient to repay the expense of putting up wires from the source to the factory, together with the cost of the two dynamo electric machines, or will it be cheaper to put up and use a small steam engine having probably an efficiency of only 1-18?

When the distance between the source and the motor is considerable, the cost of putting up the leading wires becomes important, and the question therefore arises, can two or more people use the same leading wires without increasing the thickness, or must the thickness of the wire be so much increased as to make the construction of two sets of leads as economical?

To this question I must beg your most careful attention, since the answer to it, which I hope I may be able to put it in the power of all of you to give, will decide whether the electric transmission of energy is a mere dreamer's fancy, or is likely to have a real commercial future.

In order to decide this, let us consider what proportion of the power is lost in transmitting it by electricity, and what is lost when water is used as the carrying agency. For convenience we will take the second question first.

Let W pounds of water flow per second out of a reservoir along a pipe into a town; then if there was no friction whatever in the pipe, if the pipe were perfectly smooth so that the water could slip past the surface quite easily, then the work the water could do in the town would be

W H foot pounds;

but experience shows that in reality this amount of work, when the pipe is straight, is diminished by at least

$$W \frac{4 f l v^2}{d \times 64 \cdot 4}$$

where f is a number depending on the smoothness or roughness of the pipe, l the length, and d the diameter of the pipe in feet, and v the velocity of the water in feet per second with which the water flows through the pipe. The work, therefore, that the water can do in the town is only the difference between these two last quantities, or

$$W \left\{ H - \frac{4 f l v^2}{d \times 64 \cdot 4} \right\}$$

and the loss goes to slightly heat the pipe and the water. This loss will, in reality, be even greater than what I have mentioned, as there is a certain amount of friction where the water enters the pipe at the reservoir, and additional friction at every bend of the pipe.

Now W pounds of water per second flowing, may be enough to work one man's machine, but suppose we want to increase the work done, we must if we cannot alter the reservoir, diminish the water pressure in the town, to allow the velocity of the water and the quantity flowing per second to become greater. Suppose we double v, then W will also be doubled. Double the energy will, therefore, be taken out of the reservoir, but the power furnished in the town will not be twice as great as before, since it would only be twice as great if we could both double the current and keep the pressure in the town constant; the loss, too, of power in the pipe will now be eight times as great as before, so that if we go on supplying a town in this way with motive power the loss of energy will soon become ruinous.

But there is another way in which, theoretically, we can increase the power conveyed to the town, and that is by increasing the pressure at the reservoir as well as the pressure at the town. Suppose, for example, that we double the pressure at the reservoir and increase the pressure at the town sufficiently to keep the difference the same as before, then the velocity of flow and therefore the quantity discharged will remain just the same. The waste, therefore, will not be increased, the power absorbed at the reservoir is double what it was before, while the power given out at the town is more than double what it was before, since the pressure in the town will have to be more than doubled to keep the current constant.

Such an arrangement, as far as we have gone at present, would then be a good one, since if we can much increase the pressure at the reservoir, and use at the town turbines, or water engines, working at a high pressure, we shall be able to transport any amount of power with exceedingly little loss.

Is this, then, the solution of the problem to transfer power economically by water? Theoretically, yes; practically, no. For when we talk of increasing the pressure at the reservoir how are we to do it?

We must use some kind of force pump, worked either by a steam engine, having a combined efficiency of perhaps 1-16th at the most, or by a considerable quantity of the water at a low pressure working a turbine which drives the force pump. Now, the combined efficiency of the pump and turbine will not be more than 2-5th. Taking this latter as being the larger and that assuming at the town itself we have some sort of water-motor, having an efficiency of even as much as 0·8, then the combined efficiency of the whole arrangement cannot be more than 0·32.

Again, although we have only a small flow of water, so that little of the energy will be lost from friction, the pipes must be made extremely strong to bear the great pressure, and consequently must be expensive, also it will be extremely difficult to prevent contraction and expansion of the pipes starting leaks at the joints. Now, with the water at a very great pressure, and with a very slow flow along the pipe, a very little leakage will represent a large per centage loss of energy.

Although, therefore, as far as friction in the pipes only is concerned, a a very high pressure at the reservoir, combined with the use of turbines in the town, working at a high pressure, furnishes a very economical mode of transmitting power, it is quite impracticable except for short distances.

Now, the conditions for economically transmitting power by electricity are, as we shall see, *identically* the same as those we have arrived at for the transmission by water in pipes, but luckily they are not in the electrical case by any means impracticable.

In any generator of electricity there is a certain property called the electromotive force, which means its tendency to send a current, and which is analogous with the head of water in a reservoir, inasmuch as the product of the quantity of electricity flowing per second, multiplied by this electromotive force, measures the amount of energy furnished by the generator per second, and which could be reproduced as motive power elsewhere if there were no friction. Now, the loss of energy due to electrical friction in the wires is equal to the square of the current flowing per second multiplied by what is called the resistance of the wire, a number depending on the length, the diameter of the wire, the material of which it is made, and the temperature.

Now, I explained to you that when an electro-motor was working it produced a back electromotive force tending to diminish the current. The maximum work that can be given out by this electro-motor per second, if its efficiency is unity, that is, if there is no friction or other loss of power is equal to the product of the current into this back electromotive force. There are two ways, therefore, of altering the work given out by the electro-motor per second. Either we may increase the current, or we may increase this back electromotive force. Let us consider the first case: We will double the current; then assuming that the electromotive force of the generator remains the same, which in the water question is equivalent to assuming the height of the reservoir above the town constant, we should have to let the electro-motor run at such a diminished speed that the difference between the electromotive force of the generator and the back electromotive force of the electro-motor is double what it was before. Although, therefore, we have doubled the current, and the energy furnished by the generator, we have not nearly doubled the energy given out by the motor, and the reason of this is obvious, since as the waste of power in the production of heat in the wires is proportional to the square of the current four times as much power will be wasted as in the previous case.

Consequently, just as in the case of water, increasing the current is a ruinous way of increasing the transference of energy.

Now, take the other case: Assume we double the electromotive force of the generator, and run the motor at such an increased speed that the current remains constant; to do this we must more than double the back electromotive force of the motor. The energy now furnished to the motor will be double what it was before, the energy given out by the motor will be more than double what it was before, and the energy wasted in heat will be exactly the same as before.

Consequently, just as we concluded in the case of the water, that the most efficient method to employ in order to transfer the energy, was great pressure in the reservoir, combined with turbines in the town working at a high pressure, so now we conclude that the most efficient way to transfer energy electrically is to use a generator producing a high electromotive force, and a motor producing a return high electromotive force; and by so doing the waste of power in the transmission ought, I consider, to be able to be diminished with our best existing dynamo-electric machines to about thirty per cent.; for, as experiment shows the efficiency of our best existing dynamo machines to be 0·86 (that is 86 per cent. of the power spent in revolving the bobbins is reproduced as energy of electric current); therefore, if two similar dynamo-electric machines be coupled up to transmit power, and if they are worked most *economically* in the general way I have already explained, and with the details of arrangement that I will enter into later on, instead of being worked so that the motor gives out power *most rapidly*, I have reason for expecting that the combined efficiency of the arrangement can be made to closely approach the square of 0·86, and not merely one-half, as commonly supposed.

But while the two solutions of the problem are thus identical, there is this most important difference; increasing the pressure of the water means an uneconomical task, while increasing the electro-motive force set up by a dynamo-electric machine, or an electro-motor, means merely running it faster, or running it at the same speed and putting more wire on the rotary portion.

And again, assuming that the mean electromotive force between the wire and the earth be as much as one hundred times the electromotive force producing the current, namely, the difference between the electromotive forces of the generator and of the motor, then with the ordinary insulation of the best land telegraph lines, less than one per cent. of the energy transmitted ten miles would be lost by leakage.

It would be impossible to increase indefinitely the speed of revolution of the cylinder of an induction machine, since apart from mere mechanical friction the iron constituting the core of the revolving part has to be magnetised and demagnetised very rapidly as it revolves. Now, there is a physical limit to the speed with which this can be done, and in addition this rapid change of magnetism heats the iron very much. But experiment shows that at the ordinary speed of revolution of dynamo-electro machines, 700 turns per minute, the electromotive force is proportional to the speed. We are, therefore, very far yet from the limit of speed. Consequently it would be well for the transmission of power to attempt first, a considerable increase of speed in the generator, combined with so light a load on the motor, that its speed is also very high. When this begins to fail as larger and larger amounts of power are transmitted, then we might begin increasing the amount of wire on the revolving coils of each; but this, of course, has the objection that the loss of power from a given current would then become somewhat larger.

In some of the dynamo-electric machines, the current that is sent through

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the external wires is the same as that which circulates round the fixed electro-magnets to create the magnetic field in which the movable coils revolve. Now, the small current which I am here advocating should pass between the generator at the one end of the line, and the electro-motor at the other, would be too small to properly magnetise the fixed electro-magnets of the two machines, so that even a high speed of the bobbin will not produce a high electromotive force. But this difficulty is easily overcome by the plan already employed, for totally different reasons, by Gramme, Lontin, and Wilde, in their generator for producing currents for electric lighting, viz., that of using either a separate exciter, or a separate portion of the revolving bobbin in the generator, to produce the current to magnetise the fixed electro-magnets. In connection with this current for exciting the fixed magnets, it is worthy of notice in passing, to observe that since experience shows that the electromotive force of a dynamo-electric machine is proportional to the velocity, I conclude that the magnets are saturated, and that the exciting current is already too strong, so that it may be with advantage reduced, or many fewer coils of wire employed in this portion of the machine.

We have, then, been led to this most important result, which I hope is clear to you all, and which I trust you may all carry away with you—*that a dynamo-electric machine, with a separate exciter, driven very fast with a steam engine, or with a stream of water, at high or low pressure, and sending by even quite a fine wire a small current to a distant electro-motor, also running very fast and magnetised by a separate exciter, is an economic arrangement for the transmission of power.*

We have seen, then, how to transmit electrically any amount of power through a fine wire. Now, how is this result affected by increasing the distance? Suppose we double the length of the wire, keeping the same thickness, then if we make the generator larger, putting twice as much wire on the main part of the revolving bobbin, and also make the motor at the other end larger, putting also twice as much wire on it, and if we run each at the same speed as before, then everything will be doubled, the electro-motive forces and resistances; in fact, twice as much work will be furnished by the generator, exactly twice as much as will be lost by conversion into heat, and about twice as much by leakage, so that the amount given out by the electro-motor at the other end will be about twice as great. Consequently, if we make the distance 100 times as long, using just the same thickness of fine wire, almost the same proportion will be lost as was wasted in the transmission over the short distance, provided 100 times as much energy is transmitted per second

(TO BE CONTINUED.)

RECENT PATENTS.

4686. TRANSMITTING ELECTRICITY TO GREAT DISTANCES, *E. U. Parod.—Dated 19th November*, 1878. 8*d*.

This consists in the substitution for the telegraphic cables or wires of a condenser acting as a reservoir of electricity, and extending from one end of the territory to the other. This reservoir is charged at one of its extremities, or at any intermediate point between the extremities, by any suitable generator of electricity, actuated by any of the natural sources of motive power which abound in mountainous districts, such as rapids and waterfalls, and delivers the electricity with which it is charged at as many points as may be required along its whole length, for the purpose of supplying or actuating any machines or apparatus to which it is connected.

4689. APPARATUS FOR PRODUCING THE ELECTRIC LIGHT, *E. J. C. Welch.—Dated 19th November*, 1878.—*(Not proceeded with.)* 2*d*.

A pencil of carbon is held by one end in a fixed socket, and at the other by a clip, so that it can slide freely and still maintain contact. The automatic adjustment is effected by an electro-magnet acting upon an armature connected with the clip, so that as the current increases in intensity, the armature by approaching the magnet increases the distance between the fixed socket and the movable clip.

4699. DRIVING SEWING AND OTHER MACHINES BY ELECTRO-MAGNETISM, *A. Melhado.—Dated 19th November*, 1878. 6*d*.

A hub is fixed on the driving shaft and carries a number of radial arms forming armatures which revolve in front of electro-magnets, the cores of which are circular in shape, and all the metallic portions of which are insulated, so that only the portions for attraction and conveying the current are magnetised, thereby increasing the magnetic power. The commutator is at one end of the enclosing box around the shaft; there are three metallic rollers for consecutively forming current connection with six metallic parts on the central boss. Opposite them is the contact roller for the wire line.

4707. APPARATUS FOR SECURING THE DOORS OF RAILWAY CARRIAGES AND TRAM CARS, *W. J. and R. T. Meredith.—Dated 20th November*, 1878. 6*d*.

A wooden case is placed on the top of the carriage over the jamb containing the securing bolt provided with a linked wire, terminating at its upper end in an armature placed under the poles of an electro-magnet, the negative pole of one magnet being connected to the positive pole of the next adjacent magnet. The positive and negative wires terminate on the engine, so that the driver by raising a handle connects or disconnects the wires with a galvanic battery, so that the bolts are caused to either rise or fall, and thus secure or unlock the doors. Several modifications are shown.

4711. MORDANTING AND DYEING FABRICS OR TEXTILE MATERIALS, *J. H. Johnson.—Dated 20th November*, 1878.—*(A communication.)* 4*d*.

Vegetable fibres are brought to the condition of cellulose, and then converted into pyroxiline, which is deoxidised without destroying the azotised matter, whereby the fibres thus prepared are not only mordanted in a most advantageous manner, but may also be covered by the action of a powerful current of dynamic electricity with a coating of silk or other animal or analogous substance capable of taking a very brilliant dye.

5076. ELECTRO-MAGNETIC AND MAGNETO-ELECTRIC MACHINES, *J. H. Johnston.—Dated 11th December*, 1878—*(A communication.)* 6*d*.

The inductors are each formed by two coils arranged end to end, so as to form straight electro-magnets, having poles of opposite denominations at each extremity, and which are carried upon the circumference of a plate, to which they are attached at the neutral point midway between the two coils. The coils, in which electricity is to be induced, are attached to two external plates opposite the inductors, which are arranged in such a manner as to present negative and positive poles alternately on both sides. The coils in which the electricity is to be induced when they are placed opposite an inducting coil are connected together in pairs by an iron plate, so as to convert them into horseshoe magnets, of which the plate forms the bow.

5078. APPARATUS FOR LIGHTING.—*A. P. Chamberlain.—Dated 11th December*, 1878.—*(A communication.)*—*(Not proceeded with.)* 4*d*.

Gas is generated by heat in one chamber, and the heat employed is afterwards used to produce electricity, both the gas and electricity being stored and afterwards led to a burner, the latter by wires insulated by passing through the tubing which conducts the gas.

5123. OBTAINING LIGHT, HEAT, AND MOTIVE POWER, *G. E. Dering.—Dated 13th December*, 1878. 4*d*.

The electric current generated in a magneto-electric or dynamo-electric machine is utilised for decomposing water, the resulting gases (hydrogen and oxygen) being collected in separate receivers, from which they are conducted to any point where it is required to obtain light, heat, or motive power.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES SEPT. 3.		BUSINESS DONE WEEK ENDING SEPT. 3. Highest.	Lowest.
Anglo-American Ordinary	53¼,	¾	53⅝	52¾
Do. "B"	82,	½	82¼	81¾
Do. "A"	27,	½	27½	26½
Brazilian	6½,	7	7	7
Cuba ex div.	7½,	8	—	—
Do. Ten per Cent. Preference x d.	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	—	—
Direct United States	10⅛,	⅜	10⅜	10⅛
Eastern	7⅝,	⅞	7⅞	7⅝
Do. Six per Cent. Debenture	104,	107	106½	105½
Do. Five per Cent. do	101,	103	102½	102
Do. Six per Cent. Preference	11 15-16,	12 1-16	12	12
Eastern Extension	7 13-16,	15-16	7 15-16	7 13-16
Do. Six per Cent. Deb.	105,	108	106½	106½
German Union	7½,	8	—	—
Globe Telegraph and Trust	4¾,	5	5	4¾
Do. Six per Cent. Preference	11,	½	11½	11
Great Northern	8⅜,	⅝	8⅝	8⅜
Indo-European ex div.	21,	22	—	—
Mediterranean Extension ex div.	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9,	10	—	—
Submarine	222,	227	—	—
West India and Panama	1⅛,	⅜	1 5-16	1
Do. Six per Cent. Preference	7,	½	7½	6¾
Western and Brazilian	3,	½	3	3
West. Union Seven per Ct. 1st Mt.	118,	122	—	—
Do. Six per Cent. Sterling ...ex div.	104,	106	—	—

TRAFFIC RECEIPTS FOR AUGUST, 1879.

COMPANIES.	Aug. 1879.	Aug. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,300	2,569	—	269
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	17,100	—	—	—
Eastern Telegraph Company	36,257	35,889	368	—
Eastern Extension Telegraph Company	26,242	24,870	1,372	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—

EXPERIENCED ELECTRICIAN, with knowledge of Line Construction, WANTED.—Address, stating salary required, with full particulars and testimonials, TRACY and LORRAIN, The Exchange, Liverpool.

INSULATED COPPER WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handled Cord, Silk Cord for Electric Bells, &c.—J. and W. RICKARD, Insulated Wire Manufacturers, Ashbourne-road Mills, Derby.

ELECTRICAL AND SCIENTIFIC APPARATUS.—WHOLESALE MANUFACTURERS OF ELECTRIC BELLS.—Our new perfected metallic base pattern improved Indicators and Automatic Telephone Switches. Induction Coils of highest finish; Terminals, Carbons, and all materials. Silver and Nickel Plating and Gilding Instruments made, repaired, or altered on the premises. Illustrated Electric Bell list free. Complete catalogue two stamps. Special quotations to the trade.—DALE and CRAMPTON, Electricians and Opticians, 4, Little Britain, London, E.C.

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NOTES.

THE SS. JOHN PENDER.—This vessel, belonging to the Telegraph Construction and Maintenance Company, left Sylt on September 1st for London.

THE FARADAY.—The Germanic (s), bound west, passed the Faraday on Tuesday, at 1:30 p.m., in lat. 47 45 N., long. 40 56 W., all well, and asking to be reported.

THE SS. SCOTIA.—The Telegraph Construction and Maintenance Company's steamer Scotia, from laying cable in Carimata Straits, *i.e.*, a portion of the duplicate Australian cable, arrived at Singapore on 26th August, and would leave for London in two or three days; the Edinburgh arrived at Suez from Singapore on Friday last.

THE CAPE CABLE.—The Calabria (Telegraph Construction and Maintenance Company's steamer) arrived at Zanzibar, from London, on August 16. The Seine (belonging to the same company) arrived off Delagoa Bay, on August 17, having completed laying cable from Mozambique, would leave to lay shore end and join up, which would finish this section.

MR. JAMIESON'S LECTURES ON ELECTRICITY AND SUBMARINE TELEGRAPHY.—The prize for the best notes of these lectures, recently delivered at Malta University, has been awarded to Mr. John McGill, clerk in charge, Eastern Telegraph Company. We hope shortly to continue these lectures, and to give the examination questions propounded by Mr. Jamieson, in our Students' Columns.

CABLE REPAIRS.—The following list of telegraph cables and lines which have recently broken down, and which have been repaired, or are now in course of reparation, is given by the *Journal Télégraphique*:—

Cables.	Date of Interruption.	Date of Repair.
Neuwerk-Heligoland	Jan. 27, 1879	July 20, 1879.
Brest-St.-Pierre	Feb. 23, 1879	Aug. 10, 1879.
Rio-Grande-do-Sul-Montevideo	June 28, 1879	July 27, 1879.
Pernambuco-Bahia	July 8, 1879	July 27, 1879.
St. Vincent-Barbade	July 9, 1879	July 30, 1879.
Antibes-St.-Florent of Corsica	July 11, 1879	July 30, 1879.
Trinidad-Demerara	July 30, 1879	Aug. 23, 1879.
Grenade-Trinidad	Aug. 11, 1879	Aug. 23, 1879.
Shanghai-Nagasaki	Aug. 11, 1879	Aug. 16, 1879.
The Amoor line, near Blagowestschensk	Aug. 12, 1879	Aug. 15, 1879.
Dominique-Martinique	Aug. 14, 1879	Still interrupted
Siberian line, near Stretinsk	Aug. 18, 1879	Still interrupted

TELEPHONES IN HOSPITALS.—The use of telephonic communication is gradually being extended, and although we have not yet obtained telephonic exchanges for commercial purposes, the system is becoming more and more popular. Quite recently the Children's Hospital at Pendlebury, near Manchester, has been fitted with a system of telephones. The lady superintendent's room is thus connected with each of the six wards, the kitchen, and the pantry. As the hospital consists of six pavilions opening into a long corridor, the most distant pavilion being about 120 yards from the administrative block, it is obvious that much time and labour in running to and fro are saved by this convenient method of communication. It is especially convenient in communicating with the fever ward, thus avoiding the risk of conveying infection to other parts of the hospital. The instruments were the gift of Mr. W. P. Henderson, jun., and Mr. G. P. Dewhurst, of Manchester. They are in constant use, and give great satisfaction.

TELEGRAPHY IN FRANCE.—The telegraphic wires established throughout France will reach by the end of the current year the length of 171,500 kilometres. At the fall of the Second Empire there were 114,000 kilometres in existence, so that in eight years 57,500 kilometres of new line have been created. During this year no less than 13,000 kilometres of line will be constructed, while the average increase during the previous years amounted to only 5,000 kilometres annually. This is progress of a most practical character, and the cost of sending messages has been considerably decreased. Thus last year no fewer than 11,049,218 messages were transmitted by telegraph, which shows an increase equal to 52 per cent.; a fact showing that the principle which made the penny post so great a success applies also to telegraphic communication. By the end of this year Paris will have a direct line of telegraphic wires to each capital of the eighty-four departments, not to mention a number of large towns. With regard to foreign communications, there is a direct line between Paris and Amsterdam, Antwerp, Basle, three to Berlin, one to Berne, Braganza, three to Brussels, one to Cologne and Florence, two to Frankfort, one to Geneva, nine to London, one to Metz, Hombourg, Milan, Mulhouse, Rome, Strasbourg, Turin, and two to Vienna. There is also a direct submarine line between London and Marseilles. There are 4,821 telegraphic offices in France without reckoning those in Paris

ELECTRIC DISTILLATION OF LIQUIDS.—The influence of electricity on evaporation of liquids has long engaged the attention of physicists, who hoped to find in it the solution of some obscure problems in meteorology. M. Gernez ("Comptes Rendus") has recently experimented with reference to the subject in a new and simple way. Suppose an inverted U tube having its two closed ends traversed by platinum wires. At the bend is attached a tube by which some liquid is introduced; then a vacuum is produced in the apparatus, which is then closed at a lamp. The two wires at the lower end of the U tube covered with the liquid are connected with the two poles of a Holtz machine in action. It is then found that the liquid passes from one of the branches to the other, and always in the direction of flow of positive electricity to the negative pole. The phenomenon is very distinct and regular, and pretty rapid, the lowering of level in some tubes being more than 0·001m. per minute. The supply of electricity being uniform, the changes of level are proportional to the duration of the experiment. Further, the phenomenon is manifested in gases or vapours, whatever the pressure. By varying his experiment, M. Gernez proved that this distillation does not at all result from unequal heating of the two liquid layers traversed by electricity; also that it is almost exclusively a transport of liquid under the electric influence along the conducting sides of the apparatus. The sides must be moistened for the phenomenon to occur. The distillation

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does not take place if the liquid be a very bad conductor—*e.g.*, chloroform; but when the discharge passes the transport is more abundant the less conducting the liquid. Addition of a small quantity of acid, or alkali, or neutral saline solution to distilled water reduces the transport to a fraction of its previous value (often under 1-50th). Operating with a homogeneous mixture of two liquids, there is a partial separation of these, which distil in proportions that are related neither to the volatility nor the conductivity of the substance.

Improved Signalling Communication on Railways.—Few questions connected with the working of railways have been the subject of more ingenious inventions than those for facilitating communications between passengers and guards. The simple and primitive mode adopted on American railways of a cord running through the carriages and connected with a bell on the engine is one scarcely suited to the conditions and requirements of rapid railway travelling of the present day. Electrical communications of various kinds have been suggested, and some had been sufficiently practical in their character to be adopted upon several of our railways. At the York Exhibition a working model is shown of an invention which possesses several features of novelty and merit. It is the invention of Mr. Thomas Teale Powell, of Harrogate. It provides for a direct, immediate, and reliable communication between passengers, guards, drivers, and signalmen while the train is moving at full speed. A light insulated metal bar is placed on the four-foot way, connected with the block stations by telegraph wires. A "runner," or drag, is placed under the engine or guard's van in such a manner as to be in contact with the rail, and connected with a battery or signalling instrument on the engine or van. A direct and constant communication is thus established between guards and drivers, and with the station at each end of the block. In the event of the train being parted, the guard and the detached portion can communicate with the driver, as well as the signalman at the station. Intelligence of accident may also be sent by platelayers to the signalmen, or even to an advancing train on any portion of the line between the two block stations. Communication between passenger and guard or driver is effected by the passenger simply pulling a cord and releasing the "runner," which falls upon the insulated rail, and signals are indirectly given to driver, guards, and signalmen. The inventor claims that his system can be "effectually applied as an adjunct to the present system," and, if adopted, it would remove some of "the defects and shortcomings of the present block system."

The Edison Telephone.—On the 6th inst., a private trial of the Edison Telephone Exchange took place at the offices of the company, Mansion House Chambers, Queen Victoria-street, the experiments embracing playing on the cornet from the Exchange room in Lombard-street, singing and whistling tunes, speaking and whispering from *The Times* office in Queen Victoria-street, and speaking and singing from other offices in Lombard-street, Copthall-buildings, and Carey-street (Chancery-lane). In the office a "stick" of matter was displayed which had been set up by a type-composing machine at *The Times* office from the dictation of an Edison telephone. From the offices in Mansion House Chambers there is at present communication with ten offices, including the above, the most distant being in Carey-street. The various experiments appeared to be successful, and as Mr. Johnson, who conducted them, explained, if they can be successfully carried out at ten offices, *a fortiori* they can be carried out successfully at very many more. Mr. Johnson is the chief engineer of the Edison Telephone Company and Mr. Edison's scientific representative in this country. Great merit is claimed for the instrument on account of being able to speak in a loud or soft voice with it, so that what is said can be heard by a room full of people or by only one person, and, as was explained, the instrument is purely mechanical, controlled by electricity. After leaving the offices in Mansion House Chambers the party proceeded to the Exchange room in Lombard-street, and were shown the different wires by means of which the experiments had been conducted, and the practical working of them. There were in all twenty-four wires, and Mr. Johnson stated that out of these twenty-four distinct offices twelve combinations could be made at one time—a cross connection could be made with any two wires, by which two offices could be placed in communication.

Proposed Telephonic Exchange.—An effort is being made, says the *Manchester Guardian*, to establish a Lancashire Telephonic Exchange on the American model. The advantage to business men of being placed in instant speaking communication with persons at a distance is so obvious that we cannot doubt of the success of the experiment in a city like Manchester. In Chicago, and other important cities of the United States, the Telephonic Exchange is already an established institution, forming, as it doubtless will here, a most useful auxiliary to the means of communication possessed by the citizens. The proposal is to connect subscribers' premises by means of telegraph wires with a central office and to use Bell's telephone, with Blake's transmitter, as the medium of communication between one subscriber and another. The process of working is extremely simple. Each wire will have attached to it an electric call bell, and the clerk in attendance at the central office will, immediately he is called upon, place any two subscribers in communication by simply connecting the wires of the receiver and transmitter. The receiver's attention is called by means of the electric bell, and conversation can be carried on between the two with perfect ease and privacy. The voices of the speakers are recognised as easily as if they were conversing in the same room. By a repetition of the process others can at the same time be placed in communication, so long as the wires actually in use are not affected. The wires are to be supplied and speaking instruments and call bells placed in the premises of subscribers by the promoters of the Telephonic Exchange, and a moderate rent-charge will be required for their use. All the apparatus, it is promised, will be of the most recent and improved type. The Chicago Telephonic Exchange, which has been in operation about thirteen months, has already more than 1,200 subscribers, comprising persons engaged in every kind of business and profession, as well as the city and Government officials. The managers of the proposed Lancashire Telephonic Exchange, Mr. J. D. Tracy and Mr. J. G. Lorrain, C.E., have been connected with the telephone since its inception, and the first-named gentleman has been instrumental in founding several of the most important exchanges in America. It is little more than a week since the subject was introduced to the notice of business men in Manchester, and already about fifty of the most important mercantile firms have signified their approval of the scheme, and their desire to become subscribers in the event of its being carried out. Similar exchanges are proposed to be started in London, and in other large provincial business centres besides Manchester.

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CONTACT THEORY OF VOLTAIC ACTION.

Parts I and II.

By W. E. Ayrton and John Perry, Professors in the Imperial College of Engineering, Tokio, Japan.

Part I. (continued from page 173).

The sulphates and metals of Table X. as a Daniell, connected directly to electrometer 1·068 to 1·081 volts, increasing very slowly.

Simple cell with above zinc sulphate, 1,000 volts. An instantaneous and constant deflection.

Simple cell with distilled water. A rapid increase in electromotive force from the instant of contact of the metals with the liquid. Our first reading was 0·832 volt, but there was a rapid increase when the reading was being taken. 0·942 was our last reading, but there was still a slow increase.

The above copper sulphate and distilled water and the metals as a Daniell. 1·060 to 1·010 volts, decreasing slowly. The same cell tried again, the metals being clean, gave 0·960 to 0·951 volt.

TABLE XI.—Some Collected Results.

—	Zinc.	Copper.	Saturated pure copper sulphate.	Saturated nearly pure zinc sulphate.	Slightly impure copper sulphate.	Very dilute zinc sulphate.	Distilled water.	Ordinary water.
Zinc ...	...	−0·75	...	0·358	...	0·177	0·126	0·118
Copper ...	0·75	...	−0·028	0·113	0	−0·024	−0·074	...
Saturated pure copper sulphate	...	0·028	...	0·033	...	...	−0·071	...
Saturated nearly pure zinc sulphate ...	−0·358	−0·113	−0·033	...	...	...	...	...
Slightly impure copper sulphate	...	0	...	...	...	−0·063	...	...
Very dilute zinc sulphate ...	−0·177	0·024	...	...	0·063	...	...	...
Distilled water ...	−0·126	0·074	0·071	...	...	...	...	...
Ordinary water ...	−0·118	...	...	...	...	...	...	...

A number of results have been collected in Table XI. The numbers in a vertical column below the name of a substance are the differences of potential in volts between that substance and the substance in the same horizontal row as the number, the two substances being in contact. Thus zinc is negative to saturated pure zinc sulphate, the electromotive force of contact being 0·358 volt.

IV.

From Tables VI., VII., and VIII. we see that when zinc and copper are connected by an electrolyte the zinc becomes negative to the copper, the difference of potential seeming to be somewhat less than 0·2 volt for water, zinc sulphate, and dilute sulphuric acid. This difference of potential, added to the electromotive force of contact of zinc and copper, ought to be equal to the electromotive force of a simple cell.

The changes which occur in the electromotive force of a cell are difficult to explain. They may be due to impurities in the metals, to air condensed at metallic surfaces, to air and other gases dissolved in the liquid, &c. They seem to be quite arbitrary, and they are often very considerable. The authors have begun an investigation regarding the causes of these peculiar effects.

	From Table VIII.	$\overline{ZC}$.	Sum.	Observed E.M.F. of cell.
Pure saturated zinc sulphate...	0·191 to 0·182	0·75	0·941 to 0·932	0·907, increasing to 0·926, and still increasing slowly.
Pure water	0·168	0·75	0·918	0·832, increasing to 0·942, and still increasing slowly.

The discrepancies observable in the following comparisons may also be due to the smallness of the electromotive forces of contact which were measured separately, but they are in some part due to the unexplained changes which occur in the electromotive force of a cell. Let C, Z, and L represent the copper, zinc, and liquid respectively of a simple cell; let L_1 and L_2 be the liquid in contact with the copper, and the liquid in contact with the zinc of a Daniell's cell; let $\overline{CL}$ be the electromotive force of contact of C and L, and let $\overline{CL}$ be identical with $-\overline{LC}$. Taking the five cells of Table XI., and assuming that the electromotive force of a contact of two substances as it exists in a cell is equal to its electromotive force when measured in our apparatus, we get the following results:—

	Observed E.M.F. of Cell.
I. Daniell with pure saturated copper sulphate and nearly pure saturated zinc sulphate. $\overline{CL_1}+\overline{L_1L_2}+\overline{L_2Z}+\overline{ZC}$ $=0·028-0·033+0·358+0·750=1·103$	1·068 to 1·081, increasing slowly.
II. Daniell with distilled water and pure saturated copper sulphate. $\overline{CL_1}+\overline{L_1L_2}+\overline{L_2Z}+\overline{ZC}$ $=0·028+0·071+0·126+0·750=0·975$	0·995 mean from Table X.
III. Daniell with very dilute zinc sulphate and slightly impure saturated copper sulphate. $\overline{CL}+\overline{L_1L_2}+\overline{L_2Z}+\overline{ZC}$ $=0+0·063+0·177+0·750=0·990$	1·010 Table IX.
IV. Simple cell, nearly pure saturated zinc sulphate. $\overline{CL}+\overline{LZ}+\overline{ZC}$ $=-0·113+0·358+0·750=0·995$	1·000
V. Simple cell, distilled water. $\overline{CL}+\overline{LZ}+\overline{ZC}$ $=0·074+0·126+0·750=0·950$	0·832 to 0·942, increasing slowly.

In every case the sum of the separate contact electromotive forces is so nearly equal to the observed maximum electromotive force of the cell that we have good reason for believing that the electromotive force of contact of any two substances is constant whatever other substances may be in the circuit. With other specimens of solutions of the same name and at other temperatures very different results may possibly be obtained for the electromotive forces at the various contacts, but the interest of these experiments consists in the fact that, if the difference of potentials of each contact be separately measured in the inductive method we have described, and if directly afterwards the substances be put together to form a complete cell having one or more liquids, then the electromotive force of this cell, measured in the ordinary way, is found to be equal to the algebraical sum of all the contact electromotive forces as previously measured inductively.

That the electromotive forces of a zinc sulphate cell and of a water cell are so nearly equal seems to be rather accidental. Zinc sulphate is positive to zinc and is less positive to copper, its contact electromotive forces having to be subtracted from one another; whereas water is not so positive to zinc but is negative to copper, the contact electromotive forces being, therefore, added together.

In any complete conducting circuit (receiving no energy from without) composed of the substances A, B, . . . N, the total electromotive force is equal to $\overline{AB}+\overline{BC}+\ldots+\overline{NA}$. Now, when no changes are occurring in the circuit such as will produce a supply of energy, we know from the law of conservation of

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energy that this total electromotive force is nothing. In a compound metallic circuit, which is everywhere of the same temperature, this condition is satisfied. But it is not satisfied if the temperature varies in the circuit, and we find then that the total electromotive force $\overline{AB} + \overline{BC} + \ldots + \overline{NA}$ is no longer nothing, its amount depending on the nature of the metals and on the distribution of temperature. Again, we find that even when all parts of the circuit are at the same temperature, and one or more of the substances are liquid or solid electrolytic conductors, the sum of the electromotive force of contact is not nothing, its amount depending altogether on the nature of the supply of energy which exists in the circuit, and therefore on the chemical natures of the electrolytes and of the metals in contact with the electrolytes. In fact, the electromotive force of a voltaic arrangement depends on the chemical natures of the metals and of the electrolytes.

(TO BE CONTINUED.)

NOTE ON THE CAPACITY OF A CERTAIN CONDENSER, AND ON THE VALUE OF V.

BY C. HOCKIN, M.A.

The observations given in this Paper were first begun with the object of redetermining the value of the capacity of certain condensers employed in the practical testing of cables, and in terms of which the capacity of many cables now submerged have been recorded and published.

Dr. Muirhead and Professor Ayrton stated to me that they proposed to draw the attention of the British Association to the desirability of recognising some one condenser or condensers as a provisional standard.

Fully concurring in their views on this point, I have determined in various ways the capacity of a condenser made by Dr. Muirhead several years ago, and the particulars of which he has given in his Paper.

The agreement of the value of the condenser now with the value it had when first made is satisfactory, as showing the permanence of a well-made condenser.

The order of the experiments made was as follows :—

1. A condenser was built up of silvered glass plates insulated from each other by three small fragments of shellac.

2. The capacity of the glass condenser was determined by the "ballistic" method, the deflection of a Thompson's galvanometer needle being observed.

3. The glass or air condenser was compared with three other condensers by the null method—that is to say, the glass condenser was charged to a definite positive, say, potential, and one of the other condensers to some lower negative potential such that, when the two condensers were connected, the potential of each fell to zero immediately after the connection.

4. The capacities of the three condensers above mentioned were determined by the throw of the needle of a Thompson's galvanometer moving freely, and having a period of oscillation which was varied from 2·9 seconds to 25 seconds.

5. The rate at which the condensers lost their charge when the opposite plates were connected by a known large resistance was determined.

6. A correction in one case has been applied for absorption determined by observing the rate at which the potential of the condenser varied when, after discharging through a known resistance for given times, the circuit of the high resistance was suddenly broken.

The glass condenser was thus made.

A hundred circles of the best flat plate glass were obtained and silvered on both sides by the chemical process. They were supplied by Messrs. Farmiloe and Sons.

These were carefully examined, and any spots observed not covered by the silver were covered with gold leaf secured by a little very weak gum or by a trace of lard.

Connection was made with the surfaces of the glass plates by soldering a thin copper wire to them with an alloy of the cadmium and bismuth melting at a very low temperature.

Fifty plates had a diameter of 127 mm. and 50 were of considerably greater diameter.

The plates were built up thus.

A plate of shellac was made with flat sides by pouring melted shellac on to a stout plate of glass about 12 mm. thick, and pressing the melted lac into a disc by another similar plate of glass, the two plates being separated by slips of thin glass.

The plate so pressed was cut into small pieces, and the thickness of each piece measured, the fragments having the same thickness (within $\frac{1}{1000}$ of an inch) being placed together.

A stout piece of good plate glass was covered with tin foil, and on this in proper position three little pieces of lac were laid to support the first small circle of glass. On this three other pieces were placed over the first three pieces to support the first large circle, and so on to the end. Care was taken to select the three pieces supporting each plate of the same thickness.

The mean distance between the plates was determined by measuring the height of the pile when completed, and the height after removing the shellac separating the plates; the mean area of the shellac by weighing the fragments used and comparing their weight with that of a piece of the plate from which they were cut of such size that its dimensions could be measured with some accuracy.

The three other condensers used (called A, B, C) were :—

A. The condenser referred to in Dr. Muirhead's Paper.

B. A condenser made by Messrs. Warden and Clark at some time not known by me, and used for comparison.

C. A small mica condenser, capacity about 0·1 mfd., made in 1867, and copied from the condenser described by Professor Jenkin in his Paper, "British Association Reports," 1867.

The method of observation was as follows :—

a. The time of oscillation of a galvanometer was observed.

b. The deflection of the galvanometer needle produced by a steady current was noted, the current being either that produced by the battery employed to charge the condenser flowing through a resistance of from 500,000 to 1,000,000 ohms, or else a current produced by any other battery, the electromotive force between two points in the circuit separated by a known resistance being determined in terms of the electromotive force employed to charge the condenser.

c. The condenser was charged and discharged several times. As it was found impracticable to maintain the galvanometer needle at rest absolutely when the time of oscillation was great, the method employed was to reduce the oscillations to a small amount, 2, 3, or 4 divisions, read three successive oscillations, and discharge the condenser at the moment that the needle was at rest, and on the point of changing its direction of motion. The mean of the second deflection and the half sum of the first and third deflections are taken as the zero, and the total excursion of the needle in the case in question is not altered by the fact that the needle started from a position of rest but not of equilibrium.

In fact, let Θ be the angle defining the extreme excursion of the needle due a given impulse applied to it when it was at rest in a position of equilibrium.

θ the extreme excursion when the impulse is applied, when the position of the needle is defined by the angle θ, and is oscillating through an angle θ_2 on either side of its zero point. Then (neglecting the effect of air resistance)

$$\Theta = \sqrt{\theta^2 - \theta_1^2} \pm \sqrt{\theta_2^2 - \theta_1^2},$$

and, therefore, if $\theta_1 = \theta_2$, or the impulse is applied at the moment the needle is at the extremity of an excursion,

$$\Theta = \sqrt{\theta^2 - \theta_1^2}$$

$$= \theta\left(1 - \tfrac{1}{2}\left.\frac{\theta_1}{\theta}\right|^2 + \&c.\right)$$

$$= \theta \text{ if } \left.\frac{\theta_1}{\theta}\right|^2$$

may be neglected, as it may in all the cases occurring in these experiments.

d. Experiment *b* repeated.

e. Experiment *a* repeated.

f. The coefficient due to damping was determined. An oscillation being set up, a number of swings of the needle were observed, and the log. decrement of the deflections calculated.

Let θ_1 and θ_{n+1} be two excursions of the needle measured on the same side of the zero and separated by n complete oscillations.

$$\text{Let } \frac{1}{n}\log.\frac{\theta_1}{\theta_{n+1}} = \log. a.$$

Then if θ is the observed excursion of the needle due to an instantaneous impulse applied when the needle was at rest near the zero point, and $\beta . \theta$ the excursion that would have occurred had there been no resistance to the motion of the needle,

$$\beta = a^{\frac{1}{2\pi}\tan.^{-1}\frac{2\pi}{\log. a}}$$

If we write $a = 1 + z$ where z is small,

$$\beta = 1 + \frac{z}{4} - z^2\left(\frac{3}{32} + \frac{1}{4\pi^2}\right)$$

$$+ z^3\left(\frac{7}{128} + \frac{3}{16}\cdot\frac{1}{\pi^4}\right)$$

$$- z^4\left(\frac{61}{1024} + \frac{3}{128}\frac{1}{\pi^2} + \frac{1}{96}\frac{1}{\pi^2}\right)$$

$$+ \&c.;$$

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Or
$$\beta = 1 + 0{\cdot}25000\,z - 0{\cdot}11908\,z^2 + 0{\cdot}07369\,z^3 - 0{\cdot}03217\,z^4,$$
a convenient expression, sufficiently accurate for most practical cases.

The time of oscillation was determined as follows:—The needle was brought to rest, started by discharging a condenser through the galvanometer exactly at the beat of a chronometer. By listening to the beats, the periods of the first five swings of the needle were observed and registered, a certain number (usually ten) oscillations were then counted, and the periods of five successive swings again measured, and so on.

The mean of the first five observations, the second five, and so on were taken and treated as the time of the 2nd, 16th, 30th, &c., oscillation. No sensible change in period due to extent of oscillation was observed.

In this manner results agreeing within 0·1 per cent. were readily obtained.

The galvanometer was inclosed in an iron chest of ⅜ wrought iron with a small opening to admit the light to the needle. The zero of the instrument remained very constant even when the period of oscillation was very large—25 seconds for example.

The needles were made of little pieces of watch spring hardened and well magnetised, the lower series being attached to a brass disc fixed to an aluminium wire perpendicular to the plane of the disc, and vertically over its centre.

The results obtained are now given:—

Glass condenser as first set up.

1st series of experiments	Cap. =	0·00697 mfds.
2nd ,,	,, =	0·00694 ,,
3rd ,,	,, =	0·00696 ,,
Mean - - -		0·00696 ,,

Condenser A = 0·3324 mfds.
,, B = 0·3261 ,,
,, C = 0·0995 ,,
} By comparison with glass condenser—Thompson's method.

Condenser A = 0·3312
,, B = 0·3255
,, C = 0·1026
} By direct measurement the time of oscillation of the needle being 16·8 sec. approximately.

The discrepancy in the two values of C is due to the great absorption noticed in this condenser.

The value of B is also rather too large from the same cause.

The surfaces of forty-nine plates of diameter 0·127 mm., and separated by an average distance of 1·623 mm. from the larger plates, were discharged in this case, giving for v, without corrections, the value 296×10^6 — m. per second. The correction for the greater induction through the pieces of shellac is $+3 \times 10^6$, and for the edges of the plate -1×10^6, giving for v the value 298×10^6.

The condenser was then taken to pieces and set up again. In the second case the larger plates were separated by pieces cut from a plate of flat plate glass, and the smaller plates resting on them were insulated by three very small fragments of shellac.

The distance of the surfaces was determined in this case differently. Fifty small plates were used. The 150 slips of glass separating the larger plates were cleaned with nitric acid, brushed with a camel's hair pencil, and piled on each other on an inclined metre scale, and the total height measured several times.

The small plates were brushed in like manner, placed on each other, resting on a plate of flat glass, and another large stout plate placed on them, with a weight of about 3 kilos. The distance between the glass plates was measured with a pair of inside calipers at four points on a circle, concentric with the pile of small plates. From the data thus obtained the average distance apart of the inducing surfaces was estimated. The result was as follows:—Fifty plates, diameter 0·127 mm., distant 2·362 mm. from larger plates. Capacity, 0·005007 mfds.,

Whence - - - -		$v = 299{\cdot}5 \times 10^6$
Correction for edges -	-	$-\ 1{\cdot}0 \times 10^6$
,, shellac	-	$+\ 0{\cdot}3 \times 10^6$
Final result	-	$298{\cdot}8 \times 10^6$—say 299.

A further slight correction should have been made for the connecting wires and for the small quantity of solder on each plate, but the corrections will not be sensible within the degree of accuracy obtained by the measurements.

The final result, 298,000,000 metres per second agrees closely with that obtained by Professor Ayrton, whose method (nearly) is adopted, and with the best value of the velocity of light determined by direct experiment.

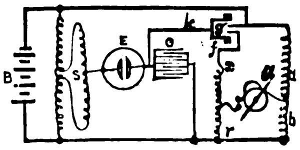
A great many measurements of condensers A and B were next made by the ballistic method. I give only the result of each set of experiments here, leaving the figures for a supplement, to show the sort of accuracy obtained in observation.

	Time Oscillation. Seconds.	Capacity of A in mfds.	Capacity of B in mfds.	
1	7·79	—	0·3276	
2	16·80	—	0·3214	
3	7·784	—	0·3218	
4	16·76	0·3312	0·3255	Mean of 3 sets.
5	25·12	0·3272	—	
6	×25·00	0·3241	0·3167	
7	×12·88	0·3248	0·3176	
8	12·32	0·3314	0·3247	
9	12·30	0·3305	0·3234	
10	2·923	0·3310	0·3219	

Sets 6 and 7 I have put down, but they may fairly be neglected, I think, because the batteries were found next day not to be in good order. In taking the mean, I reject them, and find,

Cap. A = 0·3306
,, B = 0· 323
} mfds.

To determine the capacity by loss of charge the connections were arranged as below.



B is a battery, s a Varley's "slide resistance," dividing the potential into 10,000 parts.

a, a resistance in Pt.-Ag. wire = 200,000 ohms.

b, a variable resistance.

x, a selenium resistance from 200 megs. to 270 megs.

r, a Pt.-Ag. wire resistance = 1,000,000 ohms.

The resistances a and r were lent me by Mr. H. A. Taylor, who had made them with great accuracy, and in conjunction with whom a few of the observations now given were made.

The selenium resistances were made by Mr. Bassett; the selenium bars were sealed in glass tubes with platinum terminals. The tubes inserted in holes bored in a plate of ebonite and filled in with paraffin wax, ensuring a very high degree of insulation.

C is the condenser, K a Lambert's discharging key, E a Thompson's quadrant electrometer, and G a sensitive galvanometer.

The method of observation was as follows:—

α. f and g were pressed down and b adjusted, so that $x : r = a : b$.

β. At a given instant g is raised and the slides gradually moved to the expected position of the spot after the condenser had discharged itself to the proper amount.

γ. At a given instant f is raised, the slide reading, and position of the spot noted as soon as possible, and also after given intervals.

δ. Observation α repeated.

In this way the following results were obtained for condenser B (corrected for absorption):—

Time of Insulating Condenser. Seconds.	Capacity of B.
5	0·3095
10	0·3160
15	0·3175
20	0·3232
25	3207
30	3224
35	3244
40	3203
45	—
50	3224
60	3216 3224

Omitting the first value, as 5 seconds is too small a period to be measured accurately by ear, the mean capacity of condenser B becomes 0·3211.

Without assistance I was unable to repeat with the same accuracy the experiments with condenser A. There was much less absorption with this condenser, but greater leakage, owing, I believe, to the surface of the ebonite a good deal. The mean of all values gave for A the capacity 0·323 mfds.

If, therefore, the capacity of A is defined as the apparent capacity, as determined by the throw of a galvanometer with a period of between 3 and, say, 15 seconds, I think the value 0·331 mfds. will be correct to the last figure.

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THE POWER OF THE FUTURE.

If there is one question more worthy the attention of engineers and electricians at the present day than another, it is the utilisation of the water-power now running to waste all over the world.

The process of obtaining mechanical energy, which, with a few trivial exceptions, is the only one in vogue at the present time, is a sufficiently circuitous one.

We first mine in the ground, and raise coal from considerable depths; we then burn this coal away under closed vessels, half full of water, in such a way as to convert that water into vapour a hundred degrees or so above the surrounding temperature; and we then allow this steam to pass into a moderately warm condenser, through a sort of inverse pump; the work done in its passage being equal, in the most favourable cases, to about one-fifth of the whole energy obtained from the combustion of the coal.

But when one speaks of burning coal, let us remember that it is not only coal that we are burning—it is also the very air we breath that is being consumed and rendered unfit for the maintenance of human life in a high state of efficiency. Who shall say how much of the depravity of the population in large towns is due to the habitual breathing of unwholesome and polluted air?

The coal, again, is not carbon and hydrogen only, but it contains enough sulphur to make the air which burns it not only unwholesome, but actually poisonous, a fact which is permanently indicated by its devastating influence on vegetation as well as on animals.

And even this is not all. The coal is not even completely burnt, but quantities of unburnt hydrocarbons are turned loose as smoke into the air, to hang like a pall over the face of the country, and destroy the beauties of all the valleys now occupied by great industrial centres.

These are the evils which the steam engine, great and grand as it is, has done for us. It has had a long and useful existence; it is still in full vigour, but its days are numbered. Looked at economically, it wastes four-fifths of a total supply of energy, a supply which is rapidly decreasing, and which must ultimately give out. Looked at socially, æsthetically, or morally, its results are disastrous in the extreme. To achieve the utilisation of one-fifth of the stored-up fraction of the energy of the paleozoic sun, we degrade a large population to the most loathsome labour in the pits, we consume and poison the air, and we load it with such quantities of smoke that the modern sun is barely visible.

Yes, the steam-engine will hold its ground for a few more years, it will remain in use in places for many years more, especially in its larger and more perfect forms; but it has reached its zenith, and henceforth its use will diminish, and its place be gradually taken by the wholesome natural source of power abundantly available to us.

Why should we laboriously and wastefully evaporate water by means of coal, when the sun of to-day is constantly evaporating so very much more? The power almost entirely neglected is vastly greater than that which we at present obtain from all the steam-engines that ever were made. Falling water does more work in this world in each minute than all our steam engines can do in a century.

The sun evaporates the ocean, gravitation forces up the vapour by drawing down the heavier dry air, and then, when it is condensed, gravitation draws it down again without any trouble on our part; and of all this vast quantity of descending water we utilise, perhaps, the billionth part in turning a few thousands of paltry water wheels!

Why, Niagara alone expends energy at a greater rate than all the steam engines in the world!

These facts have long been known, but the difficulty always felt has been that water-power and great industrial centres are not frequently close together, and the power could not be carried to a distance. But this difficulty of transport no longer exists. Every tyro in electrical science now knows that it is readily possible to generate an electric current by water, or any other mechanical power, that this current will travel any distance, and will there quietly, and in the most cleanly and inoffensive manner, reproduce a great part of the mechanical energy expended on it.

The machines for practically effecting this have made rapid

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strides of late years, but we must admit that they are still far off perfection. Their improvement, however, is only a question of time. The machines will be forthcoming without any doubt. The thing can be done. In twenty years it will be done. The Americans will do it if we don't.

It is the natural and proper mode of distributing a central power, and once it gets a start it will grow with prodigious rapidity.

The attention of engineers has been directed to the subject by Dr. Siemens and by Sir W. Thomson, and recently it has been brought before the populace by Professor Ayrton in his admirable lecture to the working men of Sheffield.

Sheffield itself is remarkably favourably circumstanced, and ought to be one of the first towns in England to put the ideas into practice. It has a large water supply, much too large for its present needs—the water from all the adjacent hills being collected in great reservoirs in the higher valleys, and conveyed into Sheffield at the rate of fourteen million gallons per diem. A gigantic new reservoir is just constructed which will, with the old ones, enable the company to store up sufficient water to supply Sheffield for six months at the present rate of consumption without another drop of rain.

In one valley alone there are three huge reservoirs, Strines, Dale Dyke, and Agden, the waters of which are constantly flowing from one into the next at a lower level without doing any work in the passage whatever. Every drop might be passed through turbines or other engines before being supplied to the town. From the high level reservoir of Red Myres, again, a quantity of water, estimated at at least three million gallons per day, tumbles almost precipitously in many places down a height of 400 feet before it is stored in the reservoir which is directly used for supplying the town. This fall of water is only four or five miles from Sheffield. It is equivalent to 250 horse-power, and it is at present entirely wasted. What is to prevent the engineer of the Water Works Company from utilising all this fall of water to drive magneto-electric machines by means of overshot water wheels; from conducting the electricity into the town by copper rods supported on telegraph poles, and from supplying contracting houses with the power they require for grinding and other purposes. The return current could go back most of the way by the water pipes themselves.

There must be a great source of income lying ready to the company's hand in this direction, and the water will be in no way damaged or diminished in quantity. Its potential energy has to be taken out of it somehow, and it may as well be utilised as run to waste.

A few small shops are now supplied with water power, called compensation water, by the company; but, in the first place, their small and irregularly-working water wheels do not utilise one-half of the available power supplied; and, in the next place, since they are at a low level, the tail water is useless for ordinary purposes of supply and is simply run to waste. How much better would it be to provide these shops with electro-magnetic engines, and to supply the electric current.

The power available in a case like this, when the water is collected in artificial works, cannot, of course, be sufficient for the large firms, but there are a number of small grinding and polishing shops worked by a few men, from five or six up to thirty, who would gladly avail themselves of a source of power like this, manageable, cleanly, and capable of being turned on and off at will. The large firms can have an efficient and constantly working steam-engine, and, for the present, would derive no benefit from change; but small steam engines are troublesome, expensive, and inefficient, stoking has to be performed, steam got up, and a host of other operations made, which, all put together, would make small firms willing to pay many times the cost of steam per hour for a power which would give them no trouble and could be turned on and off, as Professor Ayrton puts it, like gas.

Again, why should not the waterfalls of Wales be utilised? The Ogwen falls have a drop of 100 feet, they are supplied by a natural reservoir which only wants improving a little to make their flow constant, and they might easily supply the Penrhyn slate quarries with power.

Any town which, like Shrewsbury, is on a large river, might utilise the flow by means of a number of undershot wheels, one in every arch of a specially constructed bridge; magneto-electric machines being arranged in little rooms built inside the several piers.

The details of the whole scheme, of course, want perfecting; many of them have still to be invented, but they are only details. Some time must elapse before the scheme can be put into effective practical operation, but it must be done sooner or later. The Falls of Niagara will be the great source of power, and will eclipse all our tiny supplies; but, nevertheless, much can be done even in England, and if the Sheffield Waterworks Company, who have shown so much enlightenment and foresight in the construction of their splendid works, will only take the lead and make the necessary trials, and overcome the practical difficulties, they will not only deserve well of their generation, but, we venture to predict, they will find in the supplying of water power by means of electricity a splendid source of revenue, not wholly incomparable with that which they already obtain from the supply of the water itself; this latter normal function of a water company being, of course, in no way interfered with.

What can be accomplished, however, in such towns as Sheffield and Manchester, which have a large supply of high level rain water artificially collected for domestic and manufacturing purposes, is only trifling compared with that which can be done by large rivers and waterfalls, and by itself it could never work the revolution we have been predicting; it could never abolish coal smoke from our landscapes. It seems, however, to be the department in which a beginning may most easily be made. And for the rest, it will be a question of the survival of the fittest. Large steam engines will for a long time remain; small ones will be superseded by electro-magnetic engines driven by electricity, supplied either by water-power or by a large central coke-burning steam engine. Gas will supersede the crude burning of coal for cooking and warming purposes, and a smokeless millenium will set in which will rejoice the heart of Mr. Ruskin.

THE PSEUDOPHONE.*

BY PROFESSOR SILVANUS P. THOMPSON.

The Pseudophone is an instrument whose object is to illustrate the laws of the acoustic perception of space by the illusions it produces, just as the Pseudoscope of Wheatstone illustrates the laws of the optical perception of space by the ocular illusions it produces.

The Pseudophone consists of certain adjustable reflectors which can be attached to the head, and which perform the functions of the natural pinnæ in ordinary hearing. According to Steinhauser's theory of Binaural Hearing, the acoustic perception of space depends upon the relative intensity with which a sound-wave is received into the two ears, this again depending on the conformation and position of the head. Though in general true for many sounds, this theory fails to account for certain observed facts in the perception of sound, and fails in so far as it neglects differences of phase and of pitch.

Experiments made with the Pseudophone indicate the direction in which Steinhauser's theory requires modification.

* A Paper read before Section A of British Association.

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CORRESPONDENCE.

THEORY OF VOLTAIC ACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your reprint of the paper on the "Contact Theory of Voltaic Action," by Professors Ayrton and Perry, there is a parenthetical note at the top of p. 159, in which it is stated that in their apparatus

(a) "The difference of potentials between a substance and the air in contact with it . . . may constitute at times the larger portion of what is measured."

A little further on we have a definition of the contact theory.

(b) "At the surface of contact of two conducting substances there is an electromotive force of definite amount, which tends to make electricity flow from one of the substances to the other."

Now, as is stated by Professors Ayrton and Perry, they did did not measure the potentials of the surfaces of the various metals and liquids with which they experimented, but only that at a surface in the air near them; therefore, if (a) be true (b) cannot be proved or confirmed by any of the experiments described in this paper, or indeed, as far as I am aware, by any other contact experiments made hitherto.

It is possible that this note (a)—added since the publication of the paper in the *Proceedings of the Royal Society*—is the result of considerations connected with some experiments of mine, an account of which appeared in the *Philosophical Magazine* for August, 1878, and February, 1879. These experiments g (to show (if I interpret them rightly) that the difference of potential between two metals in contact depends on the difference of chemical action on each metal by the film of condensed gas or vapour on its surface. Thus copper is negative to iron when the pair is exposed to the oxidising action of watery vapour, &c., in the air, but positive to iron when acted on by hydrogen sulphide, by immersion of the pair in an atmosphere containing this gas. The metal attacked by the active ion of the condensed gas-film is here always the positive one, and other similar experiments all give the same result. Professor Ayrton would, I presume, explain this by assuming that the potential of atmospheric air over iron is positive to that of air over copper, while the potential of H_2S over iron is negative to that of H_2S over copper, but if these changes of potential are always found to follow and coincide with the chemical action of the gas-film on the metal, are we not bound to conclude that the difference of potential is due to the chemical action, and that the seat of the electromotive force is not at the "surface of contact" of the two metals, but at the place of chemical action on their exposed surfaces.

Moreover, these changes of potential in the air cannot be attributed to the "Contact Theory," since according to our definition (b) it is only "*conducting* substances" that are capable of producing the contact effect, and air is not a conductor. It is much simpler, and I believe truly correct, to attribute the difference of potential to the presence of static charges on the surfaces of the gas-films condensed on the connected metals, which charges are produced by the difference in the chemical action on the two metals in conjunction with the electrolytic decomposition of the condensed gas-film.—Yours, &c., J. BROWN.

Belfast, Sept. 8, 1879.

ON A GALVANOMETER FOR DEMONSTRATING THE INTERNAL CURRENT TRANSMITTED THROUGH THE LIQUID WITHIN A VOLTAIC CELL.*

BY CONRAD W. COOKE, C.E., M.S.T.E.

It is, of course, well known that when the external circuit of a voltaic cell is closed a current of electricity is transmitted through that circuit, and at the same time a current of equal strength is transmitted through the liquid within the cell from one plate to the other. These two are in reality but portions of the same current, and are for convenience known as the external and internal currents respectively, to distinguish that portion of the main current which flows through the external conductor from that portion which is transmitted from plate to plate within the cell. The former of these is detected by its electro-magnetic and electro-chemical effects, producing deflections in galvanometers and electroscopes, and sounds in telephonic instruments, and is utilised in all the applications of voltaic electricity.

As far as the author has been able to find out, there has not hitherto been any satisfactory means in the hands of the demonstrator of physics by which the existence of the internal current within a single cell can be made apparent. Faraday, in the course of his early researches, made the following experiment: He suspended a magnetic needle by a silk thread and lowered it into the liquid between the plates of one cell of a voltaic battery, so that its length should lie in a plane perpendicular to those of the plates, and he observed that when the needle was just below the surface of the liquid it was deflected the moment that the external current was closed. On lowering it still deeper (the current being maintained complete) its deflection gradually diminished as the depth of immersion was increased, until it reached a position about half the depth of the liquid, when it returned to zero, and after passing this depth it was again deflected, but this time in the opposite direction, its amount of deflection in either case increasing as its distance from the neutral or central point was increased. The cause of this phenomenon is obvious from the following considerations:—If a wire carrying an electric current be held *above* and parallel to a magnetic needle, the latter, obeying Ampère's law, will be deflected with an angular displacement dependent upon the strength of the current and its distance from the needle; and if the same wire be held *below* the needle, the latter will be similarly deflected, but in the opposite direction. Now, the flow of electricity through the liquid in a voltaic cell may, for the purpose of this explanation, be looked upon as made up of an infinite number of currents transmitted in a horizontal direction from one plate to the other; and when a magnetic needle is immersed just below the surface of the liquid, all these currents are flowing in one direction below it, and a corresponding deflection takes place; when, however, it is lowered deeper into the solution, a certain number of currents are flowing below it, tending to deflect it in one direction, and a certain number are flowing above it, tending to deflect it in the opposite direction, and its permanent deflection is due to the electro-magnetic effects of the difference between the two. When these become equal, as they are when the needle is at the middle of its depth, their effects on the needle are balanced and neutralised, and no deflection takes place, and when that point is passed, the currents above the needle are in excess of those below it, and a corresponding deflection in an opposite direction is given to the needle. This is an interesting experiment, but is very difficult to repeat, on account of the feeble and unconcentrated nature of the electric currents above and below the needle, and the resistance offered to its motion by the liquid in which it is immersed.

Prof. Hughes, by placing in the current of a battery an apparatus, such as a clock-microphone, or a key by which an intermittant or undulatory character may be given to its current, and holding one side of a rectangular coil of wire in circuit with a bell telephone over one of the cells of his three-cell battery, a secondary intermittent or undulatory current was induced in the coil by that portion of the primary circuit transmitted through the cell, and a corresponding ticking was heard in the telephone.

In both these experiments, however, the effects observed must be attributed rather to the external current of the other cells than to the internal current of the cell under experiment; and the author is unaware that any successful attempt has hitherto been made to construct an instrument which shall utilise *the whole* of the internal current of a single voltaic cell for the production of electro-magnetic effects. While engaged in some experiments a few years ago, it occurred to the author that if a voltaic cell were divided into two portions, having the zinc element in one portion, and the positive element in the other, and the solution contained in the one portion were connected to that in the other by a tube filled with the same liquid, the tube being coiled round a magnetic needle, a deflection of the latter, due to the current within the cell being forced by the convolutions of the tube to circulate around the needle, would be produced when the two elements were connected together, and an apparatus was constructed, which consisted of two glass tubes closed at their lower ends with perforated corks, through which the ends of the coiled tube are inserted. Within the rectangular coil of the tube was suspended a magnetic needle, and the whole having been filled with diluted sulphuric acid, a plate of zinc was placed in one tube and a stick of carbon in the other. On making connection between them by means of a wire, a slight deflection took place, but owing to the feebleness of the current, the directive action of the earth's magnetism and the friction of the pivot, the instrument was not sensitive enough to be satisfactory, and the author therefore designed the instrument shown in the diagram, and which is exhibited on the table, which consists of two glass test-tubes united together by a small tube about 2ft. long, and convoluted into two circular coils after the manner of a Thomson's Reflecting Galvanometer. Within the coils is suspended an astatic

* A Paper read before Section A of the British Association at Sheffield, 1879.

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system of magnetic needles of which the upper carries a light mirror by which its deflections may be made apparent by the movement of a spot of light on a screen. It may, therefore, in this respect be looked upon as a Thomson's Reflecting Galvanometer, coiled with liquid instead of with metallic wires. The elements are placed one in each of the little cells, and may be connected by a key; or, by placing a reflecting galvanometer in the external circuit, both currents may be simultaneously indicated on the screen and their interdependence or identity be demonstrated. The first instrument constructed by the author was made by connecting the two cells by means of a tube of india rubber coiled round two cardboard cylinders, but through the kindness and unrivalled skill of his friend Mr. Gimingham, whose name is now inseparably connected with the splendid researches of Mr. Crookes, he was able to produce the instrument on the table, in which the tubes and coils are of glass all in one piece, and it is a very beautiful specimen of accuracy of glassblowing. Below the base of the instrument is a fine slightly magnetised sewing needle, which can be rotated on a vertical axis through a small angle by means of a little lever, and by which the instrument can be adjusted to zero.

The author has been induced to bring the instrument before Section A of the British Association, in the hope that it may be useful, not only for science teaching, but for aiding investigations connected with the physical action of the voltaic battery.

HEINRICHS' ELECTRIC LIGHT REGULATORS AND ELECTRIC CANDLES.

These appliances, which we illustrate by the wood-cuts given below, were referred to by Mr. J. N. Shoolbred in his paper read before Section G of the British Association. At the request of the president of the section, Mr. Heinrichs, who was in attendance, described his system as follows:—

The inventor's object was to construct electric lamps of great illuminating power, in which various objections which apply to the known regulators and candles should be overcome. These objections are for the most part:—

1st. The short period during which the lamps will burn without a fresh supply of carbons, viz.: from one to four hours.

2nd. The length of time which elapses before a lamp becomes re-lighted after it has from any cause become extinguished.

3rd. The shadow thrown by the framework of the lamp supporting the mechanism which holds or feeds the carbons. This shadow becomes larger the higher the lamp is suspended; whilst the fact that the shadows of objects upon the ground become smaller as the height of the lamp is increased points to a considerable elevation as being advantageous.

In Heinrichs' Regulator and Candles, the use of carbons curved in the form of a semicircle allows of a large supply of carbon within a small compass. Thus, a ring twelve inches in diameter gives a length of over thirty-six inches of carbon rod, which if rectilineal would be difficult to manufacture and to handle. This length of carbon, about twelve millimetres in thickness, will burn for a period of twelve hours with a current of from 1,200 to 1,800 candle power. Thus the first objection is overcome. In regard to the second, a mechanism described below is employed by means of which the lamp, should it become extinguished, is relighted in a period of time so short that the eye cannot detect any cessation of the light. And in regard to the third objection, the mechanism which holds and feeds the carbons is in Mr. Heinrichs' regulator and candles placed above the arc, so that no shadow is thrown downwards, and there is consequently no loss of light in this direction.

Fig. 1 shows the regulator, in which the semicircular carbons become separated, and are fed, by means of a new feeding arrangement. The feed of the carbons takes place step by step, and prevents the carbons from ever coming into actual contact whilst burning. The carbons are brought together by the weight of the two metal arms which hold them. These arms are connected, by means of two chains, with the pulley, as shown; and the latter is in gearing with the spindle to which are fixed the escapement and ratchet wheels. The lever $L_{,}$, with its pawl, acts upon the ratchet wheel in order to effect the separation of the carbons to the required extent; and the lever L, with its two pallets, acts upon the escapement wheel to produce the feed of the carbon by the following mechanism:—When a current is sent through the apparatus in order to produce the light, it passes through the coils of the electro-magnets M and $M_{,}$, thus causing both armatures to be attracted and bringing both levers, L and $L_{,}$, into action. The latter, by leaving the position shown by the dotted lines, releases its pawl and allows it to fall into the ratchet wheel, moving it so as to separate the carbons sufficiently to produce the light. Before, however, this lever ($L_{,}$) comes to rest, it raises the pawl from the ratchet wheel by means of the stud $s_{,}$, thus leaving the wheel free. But at the same time the lever L comes into action, and its outer pallet holds the escapement wheel, thus maintaining the carbons apart. But when by the burning away of the carbons the distance between them becomes too great, the current is correspondingly weakened, and the magnet M loses some of its attracting power, and thus allows the spring between the inner pallet and the lever L to press backwards this lever with its outer pallet. This allows the escapement wheel to advance nearly by one tooth; but by the action of the spring the inner pallet which is pivotted to the upper end of the lever L is pressed forward and stops the motion. By this advance the carbons come sufficiently together to increase the current, the magnet M gains power, the armature

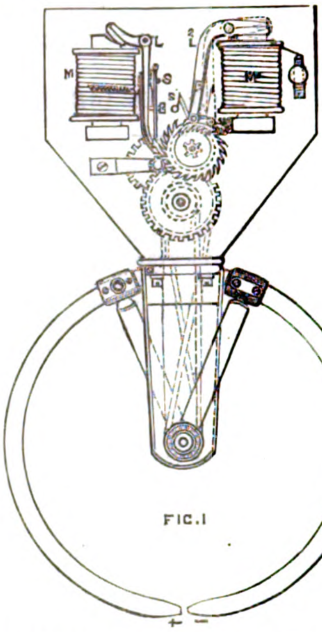
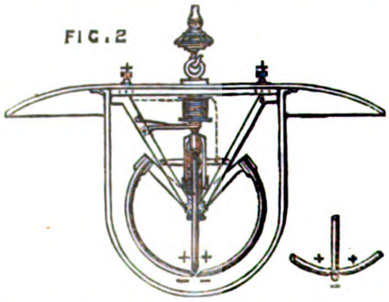


FIG. 1

is slowly attracted into its former position, the lever L presses the inner pallet against the stud s, thus allowing it to leave the escapement wheel, and thus the remaining portion of the motion through one tooth is accomplished, and the arrangement is ready for the next step in feeding the carbon. But should the current fail altogether, both levers will be withdrawn by the action of the spiral spring shown on the magnet M and the spring attached to the armature of $M_{,}$, and there is then nothing to prevent the carbons from coming immediately into contact. The spiral spring here referred to is so weak that it is able to withdraw the lever L only when no current passes. Thus should the lamp from any cause become extinguished it is instantaneously relighted by the carbons coming into contact, and by the action of the separating mechanism above described.

Mr. Heinrichs then described the electric candle shown in Fig. 2, in which no clockwork or mechanism is required

FIG. 2



for feeding the carbons. In this apparatus two sets of the semicircular carbons are used, constituting two segments of circles crossing each other at right angles; the arc being produced between the carbons at the point of crossing. The lower carbons are connected to the negative pole of the source (when a continuous current is employed); the upper set, which is movable and fixed to the armature as shown, being connected to the positive pole.

When no current passes, the upper carbon rests upon the lower; but, as soon as a current is transmitted through the apparatus, the upper carbon is raised by the attraction of the armature, so as to separate the carbons to a sufficient distance to pro-

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duce the arc. The feed of the carbons takes place automatically by the weight of the metal arms which hold them. The two views of the carbons at the point where the arc passes show how they become affected by a continuous current. When alternating currents are employed, the four points all obtain a pointed form. A candle of this form may be constructed to burn from 10 to 24 hours, without replacing the carbons. In order to obviate the resistance opposed to the current by long carbons, these are electro-coated with copper. It is stated that carbons of circular form, as manufactured by Messrs. Johnson and Phillips, are not more expensive than those of the ordinary form.

An exhibition of the lamp above-described took place at the works of Messrs. Tasker and Sons, Sheffield, on the 27th ult., and attracted much interest on the part of members of the British Association.

CHARGE OF LIBEL.

Mr. Isaac Montgomery Gadd, of 50, Palmerston-buildings, proprietor of a newspaper called the *Investigator*, was summoned at Guildhall on September 4 for publishing in that paper a series of libels on Mr. Alexander Angus Croll, one of the directors of the United Kingdom Electric Telegraph Company (Limited).

Mr. Metcalfe, Q.C., and Mr. Williams appeared for the complainant; Mr. Houghton for the defendant.

Mr. Metcalfe, in opening the case, said that the charge against the defendant was that of libelling Mr. Croll, who was a director of the United Kingdom Electric Telegraph Company, which, under the Act of 1866, was taken by the Government in 1869 under the control of the General Post Office. When the company was about to be started, a Mr. Allan proposed a scheme, or an idea, to the company, which he stated was an invention, and they purchased it for a certain sum of money. Since then Mr. Allan had died, and there seemed to be some litigation between the widow and the executors. But with that he had nothing to do. There was also litigation between the executors and the directors of the company; but into that it would not be necessary to enter. In February last a memorial was presented to the Lords of the Treasury in which the directors were accused of having falsified the accounts, made fraudulent representations, and by those means obtained of the Government £400,000 more than the company was worth. That memorial was alluded to in the House of Commons, and an inquiry was instituted into the truth of the allegations. The Chancellor of the Exchequer inquired into the matter, and ascertained that they had paid no more money for the company than they ought to have done; that the payment made to the company was not based on any false representation made by the directors. The report which the Chancellor of the Exchequer received was from Messrs. Welby and Richard Mills, whom he appointed as a committee of investigation, but into that report he (Mr. Metcalfe) would have no cause to go. Finding that they failed in that direction, a bill in Chancery was filed, which was heard by Vice-Chancellor Bacon, and he dismissed the bill. Upon that an appeal was made, and is now pending before the Court. He would, however, not have to go into the many circumstances that he had mentioned; he merely alluded to them in order to show that the defendant could not plead ignorance as to the facts he was writing upon. Pending this appeal the directors of the company had been attacked on every side, not only in the regular publications, but even in publications which had been started for the purpose of advocating the cause of Mrs. Allan. Mr. Gadd and others were flooding the country with these statements, which were of a most detrimental character to the directors of the company, and the object of the present proceedings was to put a stop to it. The report he referred to was printed in May last, and it stated that there was no ground whatever for the statement made to the Government in the memorial. Among the new publications started was one called the *Investigator*, which was registered by Mr. Gadd, and in it he thought proper to champion the case of Mrs. Allan. It was started on the 12th of July last, and in that number there was the following notice to the reader:—"We shall also publish a review of the transactions in connexion with the United Telegraph Company; how the Government was made to pay an excessive charge of £400,000, and who got the money." In the following week the defendant began his article by calling the attention of the public to the purchase by the Government of the before-mentioned company, and stating that by the advice of Mr. Scudamore and Mr. Croll they paid three-quarters of a million to the company, which was about £400,000 more than ought to have been paid, and that this result was arrived at by the falsification of accounts and misrepresentation, that the ratepayers would have to pay this amount, and that the Government had declined to face the awkward facts which an investigation would bring to light. The learned counsel then proceeded to read the libels in detail, which went through six numbers of the paper. He pointed out that the libels stated that the allegations contained in them had never been contradicted, whereas they had, as a fact, been contradicted in the committee of inquiry and the Court of Chancery.

Mr. Houghton remarked that before the case went any further he begged to say that he had only recently been instructed, and he would therefore ask that it should only be gone shortly into on that occasion and then adjourned. He was instructed that the defendant would not withdraw any of the assertions made in the memorial, but would prove them, and, therefore, he asked for time in order that he might examine the evidence he should have to produce to support the assertions.

Mr. Metcalfe said they were not going into the question of fraud or falsification of accounts, which were questions now pending before the Vice-Chancellor; nor were they going into the inquiry which had been made by the Government. But what he should proceed to deal with was the assertion in the articles that the directors had defrauded the Government of £400,000 by false representations. He should confine himself to that.

Frederick Clark proved the purchase of the papers.

Mr. Richards (Messrs. Richards, Glanville, and Co., printers, of St. Mary-axe) stated that he printed the paper for the defendant.

Samuel Hayman, clerk to the Registrar of Joint-Stock Companies, produced the proceedings of the company to which this paper belonged.

Mr. Metcalf said that Mr. Croll was anxious to get into the box in order to contradict the statements contained in the libels.

Mr. Alexander Angus Croll then said he was a civil engineer, and resided at Granard Lodge, Roehampton. He had been a magistrate for Middlesex for more than a quarter of a century, and for Surrey for upwards of 12 years, and had served the office of sheriff for the city of London. He had been a director of the United Kingdom Electric Telegraph Company, and had associated with gentlemen of the highest respectability. The directors at that time included among their number several members of Parliament. The whole of the directors were men of high honour. Mr. Allan, at the starting of the company, took an interest in electricity, and represented to them that he had an invention which he was anxious to sell them, but it turned out to be no invention at all. Nevertheless, the directors, being gentlemen of high honour, determined to give him something, and they accordingly did so. They determined to float the company in any circumstances, and in order to do so they made themselves personally responsible for £50,000, which was a foolish thing for them to do; and when they issued they did so in order to recoup themselves for the money they had made themselves liable for. It was true that they issued shares at 50 per cent. discount, but they offered the whole of them to the shareholders, who, by taking them, were in no worse position than if they had previously had them at par. There was not one single word of truth in what was stated in the libels. In their representations to the Government there was not the slightest approach to fraud, falsification of accounts, misrepresentation, or anything of the kind. If they had had their fair proportion of the money paid by the Government to the different companies, they would have had some hundreds of thousands of pounds more than they had.

Mr. Houghton asked leave to postpone his cross-examination, which was agreed to, the defendant being admitted to bail in his own recognisance of £50.

On Tuesday last the hearing of this case was resumed.

Mr. Croll was cross-examined by Mr. Houghton. He said: I told you on the last occasion that there was no foundation for the imputations contained in those charges. I wish to be tried by the highest standard of truth and honour, and I still say there is no foundation for any of those charges. I first heard that Mr. Gadd made those charges about the beginning of this year. An accountant sent to me to say that he wished to see me particularly. I could not go, and sent my clerk to know what it was. He brought back a printed copy of a memorial, which, it was stated, was to be sent to the person to whom it was addressed, but that out of kindness they had sent it to me. I took it to my solicitor, and he told me not to give it up. I therefore kept it. Mr. Gadd did not demand money from me, but it was plain on the face of the memorial that it was for the purpose of obtaining money. I was a party to the Chancery proceedings, but Mr. Gadd was not. Money has been demanded from me since the memorial. I believe that those articles might influence the result in the Court of Appeal.

Sir Thomas Owden: When articles like those appear, some persons might think there was truth in them and would be

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biased by them, while others might think there was no truth whatever in them.

Witness: I heard that the memorial had been presented to the Government through a question put to them in the House of Commons. On the 30th of April I made an affidavit denying that there was any truth in it. The memorial was presented about the 16th of April. I made a communication to the Government after the notice had been given by Mr. Fortescue Harrison. I was not present at any of the inquiries that were made, and as far as I know there was no investigation at all.

Sir Thomas Owden said that the memorial had been submitted to the Government; they had inquired into it and had expressed themselves as perfectly satisfied that the charges were without foundation; but still the charges were repeated in the paper, and this must be very injurious to the directors. With regard to the course pursued of proving the truth of a libel, even if that were done it would not affect his decision, for he must send it for trial.

Witness continued: Mr. Allan made a claim against the company, and counsel advised that he had no claim. Mr. Allan had brought sixteen actions against the company, and they had all been decided against him. At one time the company was anxious to retain Mr. Allan's services, when he was a servant of the company, in the belief that he had an invention, and that his Act of Parliament might be useful to them. That was about twenty years ago. The uniform rate was at that time in France and Belgium, and the invention had no commercial value. He (Allan) had had an Act of Parliament, but it had lapsed and was valueless. We put up our poles and were indicted as a nuisance—among others, by Baron Rothschild. The nominal capital of the company was £150,000. We thought we had an Act of Parliament, but the public knew better and would not take the shares. The directors subscribed for 1,600 shares and paid up the calls in advance to carry on the company. The directors paid up the calls in full, less the directors' fees, which were much less than they were entitled to by the articles of association. I cannot say how much was paid in fees, but we never had one penny that we were not strictly entitled to. We were entitled to £4,000 a year fees, but we never had it. The solicitor to the prosecution was then the solicitor to the company. The directors paid up their shares some time before the transfer of the company to the Government. At that time the directors held 10 per cent. preference shares. I do not know how many preference shares I held then, but 1,500 were allotted to me at the time they were allotted to others. I had sold some. I made considerable profits on the shares. The £2 10s. shares were converted into £10 shares, so that that would make a profit of 300 per cent. The directors made that profit in common with other shareholders. When the company was sold to the Government the award was made in accordance to the claims upon the company. There were the 6 per cent. and 7 per cent. debentures and the £10 preference shares. Mr. Scudamore and I based our award on the profits of the company and the shares according to the basis laid down by the Act of Parliament. When the Government were about to take possession of the company they had clerks there for six months and investigated every item of the accounts before they took over the company. Mr. Scudamore and I had nothing to do with that. They did not make out our balance sheet, we did that; and then the Post Office authorities analysed our balance sheets with the investigation made by their own clerks. The cheapest purchase of the Government was that of the United Kingdom Telegraph Company.

Mr. Houghton: Did not the directors divide among themselves £111,000?—How could they do that when they received only £100,000?

Mr. Houghton: Do you mean to say that you sold that company to the Government at the same price that you would have sold it to a private individual?—I mean to say that we sold it for much less than it was worth, and I have regretted it ever since. If we had it again we would not part with it. The amount received from the Government for the company was £562,264, and that was distributed according to the award of Sir John Hawkshaw. The Government did not pay on the assets of the company, but on the profits. If the assets of the company were less than the capital, that would not affect the question. The award was made on the basis of the profits. The £100,000 preference shares were issued at 50 per cent. discount. Interest was paid on the £100,000 10 per cent. preference shares from the date of their issue. It was paid in cash, and not by debentures. The minute-book is in court. I do not remember when the 6 per cent. debenture loan was borrowed.

Mr. Houghton said he had considered what had fallen from the Bench, and considering that, no matter how good the defence might be, his worship would have to commit the defendant for trial, he would not at present call the evidence he had to call. At the same time, he maintained that the defendant had acted throughout the matter without malice and as a journalist, believing that he was doing his duty. He would ask only a few further questions of Mr. Croll, and then let the defendant stand committed for trial.

Mr. Croll said that the total cost of construction was £347,187, and that included the discount on the £100,000 10 per cent. preference shares. Everything up to a certain period was charged to capital account. The profit was about £16,000 a year, but he could not tell whether in that account had been charged the £4,000 a year for directors' fees.

The case was then adjourned until Friday for the depositions to be copied, and the defendant was admitted to bail in his own recognizances in £500.

AN ELECTRIC RAILWAY.

Some particulars respecting the electric railway which has been in operation at the Berlin Industrial Exhibition are given in the *Archiv für Post und Telegraphe*, from which it appears that this new exemplification of the application of electricity as a motive-power sprang from a question addressed by Herr Westphal, a master builder of Cottbus, near Berlin, as to the possibility of utilising the force generated by coal burnt at that village by transmitting it to Berlin. The problem ultimately resolved itself into the question how far electric force could be employed as a motive-power on rails. The experiments which were instituted were successful, and led to the construction of the electric railway, as it has been seen in operation in the Berlin Exhibition. The arrangement is as follows:—There are two lines of rails laid down, which, in a narrow-gauge line, return into themselves in a ring-shaped curve. The length is about 300 metres. In the middle is an insulated third line, consisting of an upright, continuous iron plate. The locomotive carries two rollers, with which it stands in connection with the insulated middle line. The essential portion of the locomotive is formed by an electro-dynamical machine, one pole of which is connected with the middle line and the other with the pair of outer rails, through the outer wheels. Similarly the machine which produces the current stands in the machine-room in connection through one pole with the middle line, and through the other pole with the outer pair of rails. When, therefore, the dynamical machine in the locomotive is on the railway, the electric current produced in the machine soon runs through it and causes it to rotate and to impart its rotatory motion to the wheels of the locomotive, and the latter continues to move until the current is interrupted. Even an imperfect state of insulation on the part of the rails does not materially affect the action of the machine. When the locomotive is moving its conducting wires form much better conductors than the damp earth. If the current is interrupted, the damp ground is not a sufficient conductor to keep the dynamo-electrical action going. The magnetism of the machines producing the current consequently disappears, and the result is that the subordinate stream through the earth is also interrupted. A great advantage is possessed by the transmission of electric force from the fact that the locomotive, whether moving slowly or quickly, always works up to its full power—an effect which has hitherto been an unsolved problem in mechanics. When the machine that gives the power has to do much work, and so goes slowly, the counter-currents it produces are also correspondingly weak, and the current through the conductors thereby undergoes an increase in strength to a similar extent. By this means the electro-magnetism and, corresponding to this, the attractive power of the machine are increased. The dynamo-electric locomotive has the further advantage that it carries in itself the power which can be employed as a brake, inasmuch as it becomes itself the primary or current-producing machine when it rotates more rapidly than the actual machine. In judging of the performances of the electro locomotive in the Berlin Exhibition it must be remembered that it was not constructed for the purpose to which it has been applied—that is, to propel the three elegant little passenger carriages which are attached to it. Each carriage holds from 18 to 20 persons, and all three are drawn in from one to two minutes round the circular railway of 300 metres in length. The locomotive was originally made for the purpose of drawing up coals out of a pit.

BRITISH ASSOCIATION.

ELECTRICITY AS A MOTIVE POWER.*

(CONTINUED FROM PAGE 192.)

Electric transmission of power then becomes not only practical, but very economical both for short and for long distances, if we run both the generator at the one end of the line, and the motor at the other sufficiently fast, and if we only require to transmit a sufficiently large quantity of power.

But this latter requirement is the essence of all successful trades, viz., that the per-centage of profits shall increase as the operations grow in magnitude.

We have been considering the transport of power derived more especially from natural sources; but since we have seen that by the use of electricity, properly employed, the waste of power in transmission can be reduced for any distance to about thirty per cent. of the whole power absorbed at the generator, it follows that the employment of steam engines of vast size at points outside Sheffield would be by far the most economical mode of extracting the energy out of coal. For it is at least four times as expensive to produce power with a small steam engine as with a large one; therefore,

* A Discourse delivered to the Working Men of Sheffield, August 23rd, 1879, by Prof. W. E. Ayrton.

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including the waste of power in electric transmission, the cost of production of power in small workshops would be little more than one-third as dear as if small steam engines were used, and similarly, the waste of power in any large mill or factory in its transmission from the large steam engine at its base to all the floors and machines on each floor would be very much diminished.

Consequently, it would be much more economical to work this lathe on the platform, as I will now proceed to do, by a big steam engine in Howard-street, several hundred yards away, than to use a small steam engine here for this purpose.

But you will say that in advocating the employment of electricity I am advocating a total change in our mode of producing and transmiting power. Is the probable gain worth the expense of the necessary change?

To answer this question we must consider what would be the probable minimum annual gain by the proposed change in Sheffield alone. In making this calculation we must remember that not only can electricity produce motive power, but also heat and light, and electric heating and lighting have this great advantage, that no chimneys are required.

For example, with the electric current sent here from Messrs. Walker and Hall's works I can heat this long coil of iron wire white hot, so that, when put into the vessel of water, the water, you see, in a short time begins to boil. In fact, the stoker has put coal on the fire at Howard-street and boiled water with it here in the Albert Hall.

Again, it is almost needless to tell you that electric lamps can be lighted by a current produced at a considerable distance from the lamp, seeing that I have been using several times, for projecting images on the screen, an electric lamp fed by the current produced in Howard-street. However, we will now light up this entire hall by one electric lamp, receiving its current from the same workshop, and by another for which the electric current is produced in the yard of the Sheffield Water Company by a water engine, and transmitted by the wires crossing the street, as shown in the diagram.

Various calculations have been made as to the relative cost of lighting by burning coal to produce gas, or by burning coal to work dynamo machines for producing electric currents, and it seems to be pretty certain that if a large amount of light be required in one place, that the electric light is at least twenty times as cheap as coal; Sir William Thomson, our eminent electrician, goes so far as to say that it may be made 133 times as cheap. And certainly that there is a great saving in expense in electric lighting is seen from the actual result obtained at the Albert Hall, London, which is an example, and perhaps the only example in connection with electric lighting, where the science of putting a brilliant light high up has been allowed to ride over the precedent of putting a number of feeble glimmers all over a building.

Now, the duration during which the electric light is used at the Albert Hall on any one evening is only three hours, the time of the performance, so that the cost of getting up steam before the light is used, and the waste of heat after the engine is stopped, constitutes an important part of the whole expenditure. However, including this and other disadvantages under which Dr. Siemens labours in this matter, the actual cost, including labour of men, allowance for wear and tear of machinery, &c., is only one-third of that of the former inferior gas lights, and thus a saving of about thirty shillings an hour has been effected.

And in addition to this money economy, a great and almost unexpected gain has been attained. For the smaller amount of noxious gas produced in the electric arc, than in burning the necessary amount of gas to produce even an inferior light, makes ventilation at the Albert Hall, London, now a less important question. And the smaller amount of heat at present produced causes less draught; so that, taking the two things together, the air is much more steady. But steady air of uniform temperature is very transparent for sound, while layers of air of unequal temperature are opaque to sound. Consequently this stillness of the air, arising from the use of the electric light, enables the singing and music to be better heard, an advantage of enormous importance in so gigantic a concert hall. As a striking contrast with the delightful coolness of the air at the Albert Hall, London, was the warmth of the brilliantly gas-lighted ball room at the Cutlers' Hall on Thursday evening, and which was only surpassed by the warmth of the reception offered to the British Association by your Master Cutler.

Lighting streets by electricity has not been so successful, economically, for the simple reason that, instead of having a large bright light, at a considerable height, reflected downwards, as in the Albert Hall, London, English conservatism has prevented the authorities from grasping the possibility of using for street illumination anything differing from an ordinary iron lamp post. But there can be little doubt that if a few large electric lights, high up, were used for street illumination, the same sort of result as has been obtained at the Albert Hall would be arrived at.

And in connection with the general illumination of a town by electricity, there is this important fact to be borne in mind, that all experiments lead to the result that the larger are the dynamo machines used for producing the electric light, the cheaper is the light produced per horse-power. For example, with this smallest Siemens' machine, which I have on the table, 1 horse-power gives 600 candles, whereas with the larger machine, such as we are running backwards for driving our emery wheel, circular saw, &c., 1 horse-power gives 1,500 candle-power—more than double the light furnished by the other machine; and it is said, although I cannot vouch for the fact, that with the very large machines used in lighting the Palais de l'Industrie in Paris, 6,000 candles were obtained per horse-power.

At any rate, we may be absolutely safe in saying that the cost of using gas in Sheffield for lighting large halls, such as the one we are now in, factories, and the streets, could be halved if electric currents, generated by water engines worked by hill streams as well as by very large steam engines, were substituted for gas.

But can this be quite right? for I have proved that to transfer energy economically we must use a large pressure and a small flow. Now, how can we produce a very bright electric light with a small current? Why, by not using the current that comes along the wire to produce the light at all, but merely to drive an electromotor, which motor, at the place where any large amount of light was required, would be employed in giving motion to a second dynamo-electric machine, which would produce the currents for lighting purposes.

This experiment I might show you, but as we have used already several times during the evening electric lights fed from a distance, we will vary the experiment and try an analogous one. Messrs. Walker and Hall will now, at their works, give rapid motion to a dynamo machine, and the current which, when properly arranged as I have explained to you may be small, will set in motion this electromotor. This in its turn will cause this other dynamo machine to rotate rapidly and produce a current which I will use for rapidly gilding this piece of plate.

It is not necessary for me—and, in fact, time would not allow me—to tell you how I propose to employ the electric light to illuminate private rooms, if only I can get people to throw away the notion that to light a room we must have something with a globe on it, like an oil lamp; nor is it necessary for me to remind you that by whitewashing the walls—yes, by whitewashing even the very machines themselves in some of the Paris factories, the supposed strong shadows cast by the electric light have been less than the strong shadows cast by another bright light, one that we not only put up with, but one that from the force of habit we are tolerably contented with, viz., the sun.

(TO BE CONTINUED.)

RECENT PATENTS.

5136. WATCHES FOR TRANSMITTING ELECTRICAL SIGNALS, *B. J. B. Mills.*—*Dated 14th December*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d*.

To the upper or dial side of the watch plate is screwed a spring, which is provided at its free end with an insulated pin or stud, which bears against the under side of the hour wheel with a tendency to raise the latter. The hour wheel is also provided with a stud or pin projecting from one side thereof. At the under or movement side of the watch plate is mounted another spring also provided with a pin or stud at its free end, whilst at its other end it is fixed to an insulated metallic pivot, which passes through the plate and is fixed on the other side to a block or piece to which is screwed the conductor, which communicates with one of the electrical wires. The pin or stud in the hour wheel runs on the edge of a projecting ring carried by the signalling needle, hand, or pointer, and concentric with the axis thereof.

5152. ELECTRIC LAMPS OR LIGHTS, &c., *G. Whyte.*—*Dated* 16th *December*, 1878. 6*d*.

The electrodes are in the form of edge contact discs actuated to rotate in contact at right angles to each other, the spindle being actuated and carried on separate frames, one movable on the other, in order to make up for the wear or burning away of the electrodes, the frames being connected respectively to the positive and negative poles of electro-magnetic machine. The distance between the carbon surfaces is regulated by horizontal coil magnets connected by reverse currents on each side of the raising and lowering stem of the lower disc, so that their adjacent ends grip it between them.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES SEPT. 10.		BUSINESS DONE WEEK ENDING SEPT. 10. Highest.	Lowest.
Anglo-American Ordinary	52¾,	3¼	53¼	52⅝
Do. "B"	81¾,	2¼	82¼	81⅝
Do. "A"	26¾,	7¼	27¼	26½
Brazilian	6⅞,	7	7	6 15-16
Cuba	7½,	8	7⅝	7⅝
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	—	—
Direct United States	10¼,	½	10⅝	10⅛
Eastern	7¾,	⅞	7⅞	7 13-16
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do	101,	103	102½	102½
Do. Six per Cent. Preference	11 15-16,	12 1-16	12⅛	11⅞
Eastern Extension	7 13-16,	15-16	7⅞	7¾
Do. Six per Cent. Deb.	105,	108	—	—
German Union	7¼,	8	—	—
Globe Telegraph and Trust	4⅞,	5	5	4⅞
Do. Six per Cent. Preference	11,	⅛	11⅛	11
Great Northern	8¼,	½	8½	8 15-16
Indo-European	21,	22	—	—
Mediterranean Extension	2½,	3	2 13-16	2 13-16
Do. Eight per Cent. Preference	9,	½	9¼	9¼
Reuter's	9,	10	—	—
Submarine	222,	227	—	—
West India and Panama	1⅛,	⅜	1¼	1¼
Do. Six per Cent. Preference	7⅛,	⅝	7¼	7 3-16
Western and Brazilian	3,	¼	—	—
West. Union Seven per Ct. 1st Mt.	118,	122	—	—
Do. Six per Cent. Sterling	104,	106	—	—

TRAFFIC RECEIPTS FOR AUGUST, 1879.

COMPANIES.	Aug. 1879.	Aug. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,300	2,569	—	269
Direct Spanish Telegraph Company	980	879	101	—
Direct United States Telegraph Company	17,100	—	—	—
Eastern Telegraph Company	36,257	35,889	368	—
Eastern Extension Telegraph Company	26,242	24,870	1,372	—
Great Northern Telegraph Company	16,800	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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NOTES.

Direct Spanish Telegraph Company.—The half-yearly meeting of this Company will be held on Tuesday, Sept. 30.

SS. John Pender.—This ship was erroneously said in our last issue to belong to the Telegraph Construction and Maintenance Company, whereas it should have been said to belong to the Eastern Telegraph Company.

Cabul.—The correspondent of the *Daily News* states that "immediately the occupation of Shutargardan had been effected, the laying of the telegraph from thence to Ali Kheyl was commenced, and is being expeditiously pushed forward."

Mance's Heliograph.—Twelve sets of heliographs have been sent out from the Royal Arsenal at Woolwich to Sir Garnet Wolseley; the successful signalling between the lower Tugela and Ekowe having given an enormous impetus to army signalling. Heliographic messages have been exchanged between Shooter's Hill and the Essex hills, a distance of fifty miles. Latterly a "heliogram" was transmitted from the Crystal Palace to Woolwich Common by moonlight. This mode of signalling has also been successfully utilised at night by throwing a powerful beam from a reflecting lamp on to the disc.

Silvertown Works Company.—This Company have been carrying out some experimental trials of the system for insulating underground telegraph wires, devised by Mr. Brooks, and already described in these pages. It is found that all quantities of paraffin oil do not answer for this purpose, and there was great difficulty in finding the right kind of oil. When, however, this was secured, the specific inductive capacity was found to be very low; but it is also stated that electrification is greater than with any other known insulator. Several lengths of wire insulated on this system are being worked in America.

Electro-Magnetic Stopping-Motion for Spinning Frames.—In the Augsburger Kammgarnspinnerei there is now working an ingenious contrivance, in which a current of electricity is employed to effect the stopping of the spinning frames. The apparatus consists of an arrangement for closing an electric circuit, in connection with special mechanism attached to the driving-power of the frame, and which, upon the breaking or failing of a thread, either on entering or leaving the frame, automatically stops the latter. The stopping-motion consists of an arrangement of disengaging-gear, acting directly on the driving band of the frame; of a series of thread-guides which act as circuit-closers at the entrance of the yarn into the frame, with similar guides or circuit-closers at the issue of the doubled yarn, before it is wound on the spools; and of a brake for the immediate stopping of the frame.

Alloy of Zinc and Iron formed in "Galvanising" Iron Wire, &c.—The formation of "dross" seriously troubles the galvaniser. This dross is an alloy of zinc and iron, which is formed in the zinc bath, partly by the solvent action of the zinc on the iron of the pot, but chiefly from the iron articles dipped, and from the dripping off of the superfluous "amalgam" as they are removed. This alloy carries from 90 to 95 per cent. of zinc, and from 5 to 10 per cent. of iron and impurities. The operation of removal, called "drossing," is performed with a large perforated iron spoon or ladle, through the openings of which the fluid zinc runs off, while the dross is retained, packed into shallow moulds so as to form ingots of about 75 lbs. weight, and in this form is sold to the smelters and refiners, who gain the zinc it contains either by distillation or by special patented procedures. We believe that considerable quantities of this alloy have been exported to China, where it is probably utilised in the manufacture of bells and other articles. Could not our manufacturers find some uses to which it could be directly applied?

"Edison's Slow Progress."—Under this heading the *New York Star* has an article denying that Mr. Edison has really invented anything in electric lighting. The opinion to this effect of "a gentleman who is admitted to be one of the highest authorities on applied chemistry, electricity, and cognate sciences," is quoted at great length. This anonymous authority admits that Mr. Edison "is a first-class mechanical genius," but adds that he is also "one of the best adapters of other people's ideas." He asserts that "The sum total of all that this man has ever really invented is to be found in the electric pen and the phonograph. This last discovery has so far captured the public mind that every proposition coming from Menlo Park, where this modern wonder experiments, is received with open arms and welcome." The system of quadruplex telegraphy now in use by the Western Union Telegraph Company is stated to be, not Edison's, but the invention of an electrician named Gerritt Smith, in the employ of that company. The article winds up by stating that "It is said by some of Mr. Edison's late *employés* that he has almost entirely given up the pursuit of electric lighting, and ceased to attempt anything in that line;" and that "this being so proves correct the assertion that the platinum mine theory was simply invented and used as a plank on which to 'slide down and out' of the whole electric light business." Probably Mr. Edison, or some of his friends, may have something to say in answer to these statements.

A Strange Phenomenon.—On the 23rd of August M. F. Strobl, of Linz, joined a party which was making the ascent of the Gross Glockner. The members of the party left the Stüdlhütte together at 2 o'clock in the morning, with a storm apparently threatening from the west. At 3 a.m. they found themselves in the middle of the storm-cloud, and were compelled by the Egyptian darkness surrounding them to come to a complete halt. Suddenly the storm broke out directly above their heads, the thunder and lightning, which at the same time came on, being at once awful and grand in the extreme. There were other parties ascending the mountain at the same time, and some of their guides and members, who during the brilliant lightning flashes were able clearly to distinguish the party to which M. Strobl belonged, stated, after the storm had subsided, that the electric fluid seemed to strike into and all round the company in the storm-cloud. To the six persons of whom this party consisted all nature seemed to be the scene of one vast conflagration, and they were prepared for the worst. The guide endeavoured to console them, addressing them in these words—"Gentlemen, we shall all be struck dead, but what does it matter? The lightning might have killed us even if we had been in our beds." For some

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time the lives of the members of the party did not appear worth half a minute's purchase. Moreover, every one temporarily suffered from complete blindness, owing to the overpowering intensity of the electrical display. At length, however, the power of vision began to return to the various members of the party, when a strange phenomenon presented itself to their sight. Each of the six persons appeared enveloped in all the brilliancy of St. Elmo's fire. From the hair of their heads and beards, from their coats and hats, a stream of electric sparks was discharging itself. The cords with which their hats had, on account of the violence of the storm, been fastened to their coat buttons, gave out light, while from the alpenstocks which they had stuck in the snow the electric fluid streamed out. Notwithstanding the imminent danger to which they had been exposed, none of the gentlemen were in the least injured, the only inconvenience they suffered being that they were compelled by the rain, snow, and frost to return that morning to the Stüdlhütte and defer the ascent to a later hour of the day.

Cohne's Electric Candles.—An improved form of electric candle has been patented by Mr. S. Cohné of 65, Gracechurch-street, for which the following advantages are claimed. Up to the present time all electric candles in use have been made from pure carbon or carbon mixed with other subsances, such, for example, as kaolin or plaster of Paris, all which have the great disadvantage of burning too quickly away and producing in a greater or lesser degree a flickering light. Such candles, therefore, require controlling mechanism to regulate their distance from each other. Mr. Cohné's invention consists in making or forming a candle of ultramarine or the substances which when united together form or produce ultramarine. The ultramarine may be green, blue, or of any other colour in which it is produced. It may be used either in its pure state or mixed with carbon, kaolin, plaster of Paris, molasses, or with any metal reduced to powder so as to be in a finely divided state. The metal preferred is copper, and it is ultramarine, carbon, powdered copper, and molasses that the patentee employs. To about four parts of carbon he adds one part of ultramarine and one part of the finely divided metal and as much molasses as will, when mixed with the other materials, be sufficient to form the whole into a paste which can be moulded or otherwise formed into the shape desired. The candle thus formed is dried and heated for a sufficient time by fire, by whose action all the moisture is evaporated, the sulphur is burned away, and the molasses, as well as all other organic matter, becomes carbonised. The patentee does not confine himself to the exact proportions above named, and it will be understood that the mixture alluded to is only one of those in which the candle may be made. When these candles are put into use, the resistance and the current in the arc are to a very great extent less varying, and controlling mechanism to regulate the distance is nearly unnecessary, because the candle is consumed very slowly in comparison to those heretofore in use.

Edison's New Telephone.—The *New York Herald* publishes the following description, transmitted by telegraph, of experiments with this telephone :—" Saratoga, N.Y., Aug. 30. —Mr. Edison occupied the evening session of the Science Association to-night with a description of his new electrochemical telephone, giving illustrations of its power and mode of operation. An immense audience was present, filling the Town Hotel to its utmost capacity, and the experiments were received with great interest and enthusiasm. The telephone was operated from an apartment in the building at some distance from the hall. The difference between the new instrument and the ordinary telephone consists in its capacity to convey the voice to a room full of persons without any earpiece. The sounds of the voices were very distinct, and one of the most curious features of the experiments was the conveyance of two voices distinctly at the same time, the one singing and the other repeating the alphabet. Mr. Edison stated that he could not attempt to explain the reasons for the remarkable results obtained, as he did not fully comprehend them himself. The features of the instruments are the use of carbon points, and, in obtaining the wave, he explained that the current was broken by the friction occasioned by the revolution of a piece of chalk against the metallic bar attached to the diaphragm. Several thousand vibrations of this were produced in a second of time. The revolutions are produced by the turning of a crank worked by a person in the room to which the sounds are transmitted, thus placing the transmission of sound in the hands of that person. The chalk used is saturated with a solution of phosphate of potash, which rather than any other salt produces the required result. Mr. Edison could not explain why. He only knew that he could not obtain results in any other way. Mr. Edison asserted his belief that before long a person making a speech in New York may be heard through the electrochemical telephone by a hall full of people in Saratoga, or that a concert may be given at any place by artists in another city. During the experiments the cornet was played and " John Brown's Body " was sung and transmitted with perfect distinctness and heard as plainly by all as if the instrument and voices were in the room."

What Next?—The French correspondent to one of the daily papers during the past week says "that a new reform is being advocated by the Paris press. The new reform which is suggested is to replace the guilliotine by electricity. By this means, it is argued, instantaneous death can be inflicted without the hideous and unclean concomitants of the decapitating machine, and with the certainty that the consciousness of life will not survive the blow that destroyed it. I have reason to believe that when the Chamber reassembles a Bill will be brought in to substitute electricity for the guillotine as a means of inflicting capital punishment." A short time ago it was proposed on " humane principles" to slaughter animals this way. Not long ago electricity was used as a test to determine whether an individual who feigned being crippled was entitled to the comforts, &c., of one of our hospital wards. We may well ask ourselves " What next?" As long as capital punishment exists in our penal code, there is nothing unreasonable in designing methods to divest the matter of as much of its ugliness as possible, and whilst a great deal may be said in favour of electricity, on the humane side of the question, we fear the horror of experimenting on the living subject is too ghastly altogether. There is abundant evidence to show that where death has resulted from lightning, no pain or disturbed consciousness has intervened before death. Electricity, at any rate, commends itself a long way in preference to poisoning, which was proposed in this country a few years ago for the same purpose, by some humane (?) reformers on hanging. Before this new reform can be censured, let us point to the terrible application of electricity in torpedo warfare. We see then that the subject can be more freely discussed without our being taunted with a " want of decent feeling."

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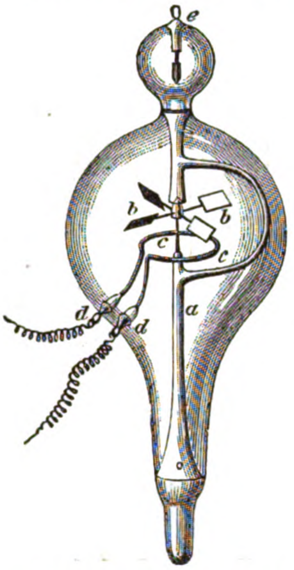
RADIANT MATTER.*

BY WILLIAM CROOKES, F.R.S.

(CONCLUDED FROM PAGE 184.)

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millims. of mercury, on passing the induction current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and rotation commences. On continuing the exhaustion, the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

Here is another piece of apparatus (Fig. 13) which illustrates



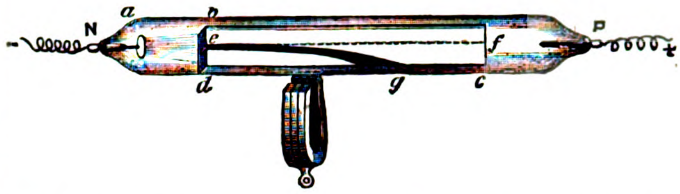
the mechanical force of the Radiant Matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin clear mica, supported on light aluminium arms, and in the centre is a small glass cap which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached, so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of Radiant Matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery; this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

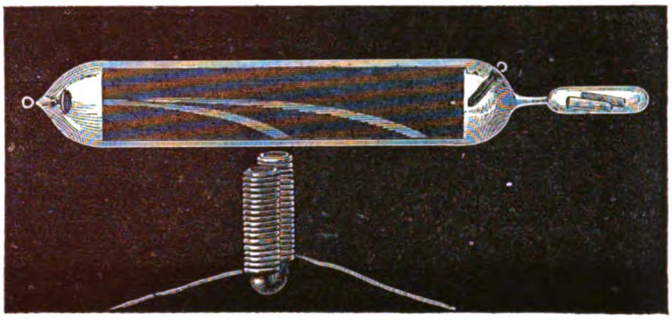
Here, then, is another most important fact. Radiant Matter in these high vacua is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

RADIANT MATTER IS DEFLECTED BY A MAGNET.

I now pass to another property of Radiant Matter. This long glass tube (Fig. 14), is very highly exhausted; it has a negative pole at one end (*a*) and a long phosphorescent screen (*b, c*) down the centre of the tube. In front of the negative pole is a plate of mica (*b, d*) with a hole (*e*) in it, and the result is, when I turn on the current, a line of phosphorescent light (*e, f*) is projected along the whole length of the tube. I now place beneath the tube a powerful horseshoe magnet: observe how the line of light (*e, g*) becomes curved under the magnetic influence waving about like a flexible wand as I move the magnet to and fro.

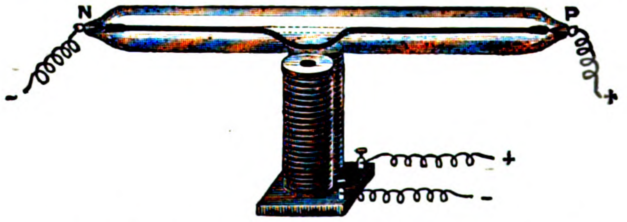


This action of the magnet is very curious, and if carefully followed up will elucidate other properties of Radiant Matter. Here (Fig. 15) is an exactly similar tube, but having at one end a small



potash tube, which, if heated, will slightly injure the vacuum. I turn on the induction current, and you see the ray of Radiant Matter tracing its trajectory in a curved line along the screen, under the influence of the horseshoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun the velocity will be greater and the trajectory flatter, and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I cannot well increase before you the velocity of my stream of radiant molecules by putting more powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of Radiant Matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half-way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of Radiant Matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I



turn on the induction spark it passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the centre towards the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of Radiant Matter had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skilfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the

* A lecture delivered to the British Association for the Advancement of Science at Sheffield, August 22, 1879.

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electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept the Radiant Matter coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly, as if it were an over-shot water-wheel. I turn the magnet so as to drive the Radiant Matter underneath; the wheel slackens speed, stops, and then begins to rotate the other way, like an under-shot water-wheel. This can be repeated as often as I reverse the position of the magnet.

I have mentioned that the molecules of the Radiant Matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago (Fig. 16), the discharge passes from one pole to another, carrying an electric current, as if it were a flexible wire. Now it is of great interest to ascertain if the stream of Radiant Matter from the negative pole also carries a current. Here (Fig. 18) is an apparatus which will decide the question at once. The tube contains two negative terminals (*a*, *b*) close together at one end, and one positive terminal (*c*) at the other. This enables me to send two streams of Radiant Matter side by side along the phosphorescent screen—or by disconnecting one negative pole, only one stream.

If the streams of Radiant Matter carry an electric current, they

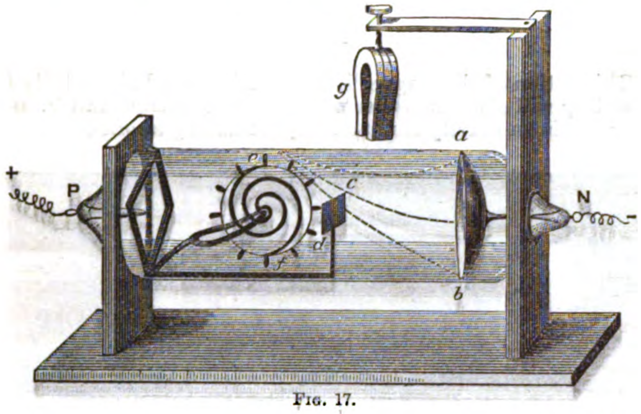

Fig. 17.

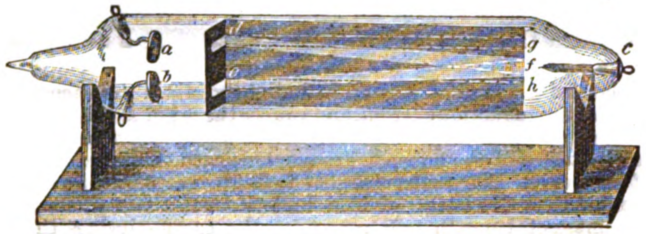

Fig. 18.

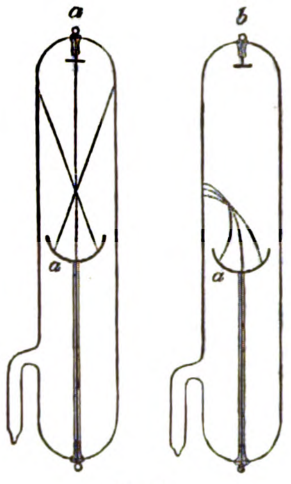

Fig. 19.

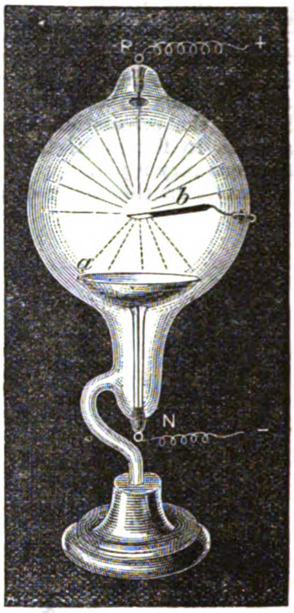

Fig. 21.

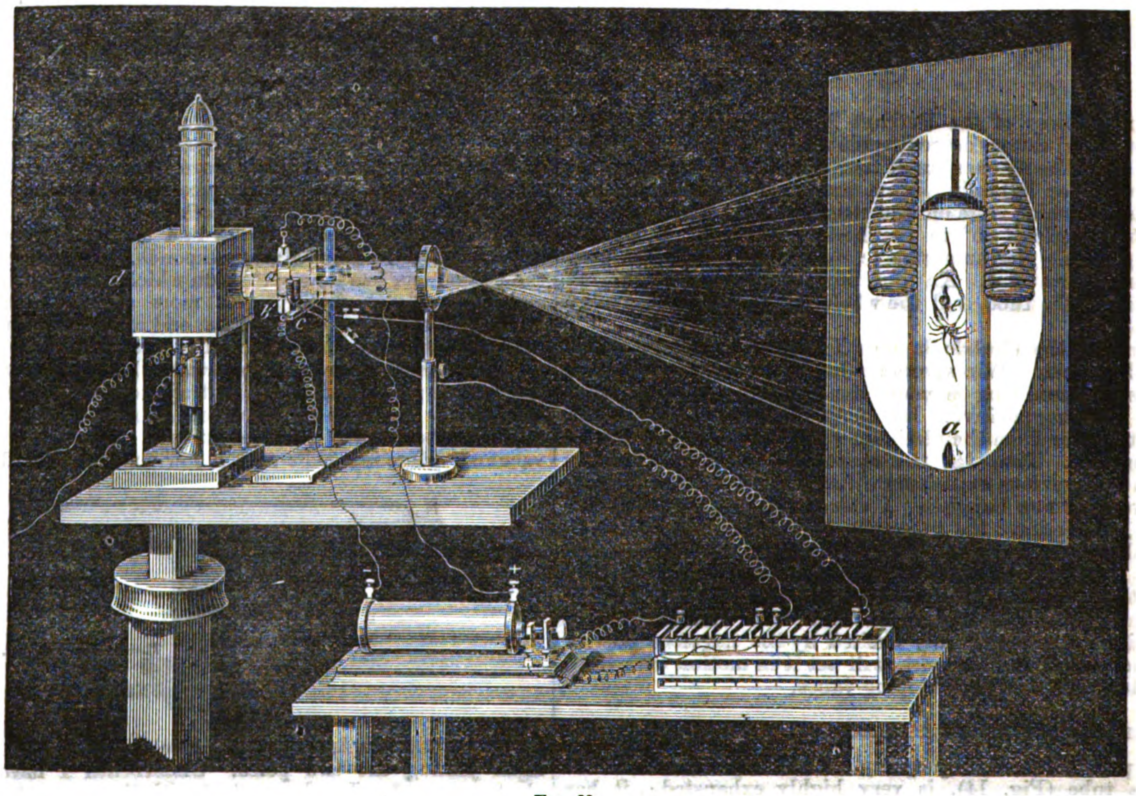

Fig. 20.

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will act like two parallel conducting wires and attract one another; but if they are simply built up of negatively electrified molecules they will repel each other.

I will first connect the upper negative pole (*a*) with the coil, and you see the ray shooting along the line *d, f*. I now bring the lower negative pole (*b*) into play, and another line (*e, h*) darts along the screen. But notice the way the first line behaves; it jumps up from its first position, *d f*, to *d g*, showing that it is repelled, and if time permitted I could show you that the lower ray is also deflected from its normal direction; therefore, the two parallel streams of Radiant Matter exert mutual repulsion, acting not like current carriers, but merely as similarly electrified bodies.

RADIANT MATTER PRODUCES HEAT WHEN ITS MOTION IS ARRESTED.

During these experiments another property of Radiant Matter has made itself evident, although I have not yet drawn attention to it. The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we saw earlier in the evening (Fig 8) is intensely hot, and I have prepared an apparatus by which this heat at the focus can be rendered apparent to all present.

I have here a small tube (Fig. 19, *a*) with a cup-shaped negative pole. This cup projects the rays to a focus in the middle of the tube. At the side of the tube is a small electro-magnet, which I can set in action by touching a key, and the focus is then drawn to the side of the glass tube (Fig. 19, *b*). To show the first action of the heat I have coated the tube with wax. I will put the apparatus in front of the electric lantern (Fig. 20, *d*), and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of molecular rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the centre of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

I can render this focal heat more evident if I allow it to play on a piece of metal. This bulb (Fig. 21) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio-platinum (*b*) supported in the centre of the bulb.

I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the metal, raising it to a white heat. I bring a small magnet near, and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down, or draw it completely away from the metal, and leave it non-luminous. I withdraw the magnet, and let the molecules have full play again; the metal is now white hot. I increase the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

THE CHEMISTRY OF RADIANT MATTER.

As might be expected, the chemical distinctions between one kind of Radiant Matter and another at these high exhaustions are difficult to recognise. The physical properties I have been elucidating seem to be common to all matter at this low density. Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, &c., are identical, only they commence at different pressures. Other facts, however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees than I can get by mere pumping. Working with aqueous vapour, I can use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the 1-20,000,000th of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

It may be objected that it is hardly consistent to attach primary importance to the presence of *Matter*, when I have taken extraordinary pains to remove as much Matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one-millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of Matter is quite a modern notion. It would seem that when divided by a million, so little Matter will necessarily be left that we may justifiably neglect the trifling residue and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must necessarily be small, whereas it may happen that the original number is so large that its division by a million seems to make little impression on it. According to the best authorities, a bulb of the size of the one before you (13·5 centimetres in diameter) contains more than 1,000000,000000,000000,000000 (a quadrillion) molecules. Now, when exhausted to a millionth of an atmosphere we shall still have a trillion molecules left in the bulb—a number quite sufficient to justify me in speaking of the residue as *Matter*.

To suggest some idea of this vast number I take the exhausted bulb, and perforate it by a spark from the induction coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes and sets them rotating after the manner of a windmill. Let us suppose the molecules to be of such a size that at every second of time a hundred millions could enter. How long, think you, would it take for this small vessel to get full of air? An hour? A day? A year? A century? Nay, almost an eternity? A time so enormous that imagination itself cannot grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfilment of the mathematicians' prediction that the Sun, the source of energy, four million centuries from its formation will ultimately become a burnt-out cinder;* supposing all this—at the rate of filling I have just described, 100 million molecules a second—this little bulb even then would scarcely have admitted its full quadrillion of molecules.†

But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole before you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that instead of entering at the rate of 100 millions every second, they troop in at a rate of something like 300 trillions a second. I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this Fourth state of Matter we seem at length to have within our grasp and obedient to our control the little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe. We have seen that in some of its properties Radiant Matter is as material as this table, whilst in other properties it almost assumes the character of Radiant Energy. We have actually touched the border land where Matter and Energy seem to merge into one another, the shadowy realm between Known and Unknown which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this Border Land, and even beyond; here, it seems to me, lie Ultimate Realities, subtle, far reaching, wonderful.

> " Yet all these were, when no Man did them know,
> Yet have from wisest Ages hidden beene;
> And later Times thinges more unknowne shall show.
> Why then should witlesse Man so much misweene,
> That nothing is, but that which he hath seene?"

---

* The possible duration of the Sun from formation to extinction has been variously estimated by different authorities at from 18 million years to 400 million years. For the purpose of this illustration I have taken the highest estimate.

† According to Mr. Johnstone Stoney (Phil. Mag., vol. 36. p. 141), 1.c.c. of air contains about 1000,000000,000000,000000 molecules. Therefore a bulb 13·5 centims. diameter contains $13{\cdot}5^3 \times 0{\cdot}5236 \times$ 1000,000000,000000,000000 or 1,288252,350000,000000,000000 molecules of air at the ordinary pressure. Therefore the bulb when exhausted to the millionth of an atmosphere contains 1,288252,350000,000000 molecules, leaving 1,288251,061747,650000,000000 molecules to enter through the perforation. At the rate of 100,000000 molecules a second, the time required for them all to enter will be

12882,510617,476500 seconds, or
214,708510,291275 minutes, or
3,578475,171521 hours, or
149103,132147 days, or
408,501731 years.

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COMMUNICATION WITH TRAINS IN MOTION.

On the occasion of the catastrophe at Montserrat our contemporary *La Correspondance Scientifique* directed the attention of its readers to the system of M. Baillehache, by which communication can be carried on between the guard of the train and the terminal or other station in which he is circuited. Doubtless, should any English line be unfortunately the scene of an accident, many persons who have read of M. Baillehache's system will feel inclined to advocate its adoption. We think such a system is not necessary, and, while we are glad to see the applications of electricity extended, we cannot recommend an increased expenditure, unless the benefit be commensurate with the outlay. Railway companies, and especially the southern lines, such as the South Eastern, have an immense scope for improvement, and any expenditure on such a system as the one above mentioned had better give place to an expenditure to provide better carriages, better stations, and, in fact, better accommodation altogether for passengers.

With regard to a train automatically signalling its position, there is little difficulty in devising systems, but any system would be expensive and require constant attention. The best known at present are Imray's, Rousseau's, and Brunius's, full information concerning which is given in Langdon's admirable little work. These, however, are not systems by which communication with the train is constant, and so differ from Baillehache's.

Let us consider shortly the means at present in use for the safe working of railway traffic, and then we shall be in a better position to judge if any extension in the direction proposed by our contemporary is required in England. Single lines are generally worked by the staff system, supplemented by telegraphic apparatus to facilitate crossing arrangements. A staff is delivered to the driver before he can proceed on the line, and as there is only one staff it is absolutely certain that but one driver can have it, and unless wilful negligence occurs there cannot be two trains upon the same section of line. On double lines the absolute block systems would render any section of line safe, if the various stations, sidings, and junctions were properly arranged. At present these, in certain places, constitute the weak point in the system. The telegraph, we may say, is almost the principal apparatus required by the block system. By it trains are signalled in, out, and past stations and signal-boxes; and, if the signalman consistently keeps any train from entering a section till he receives the "clear" signal from the next box, a collision is impossible. With such accidents as running off the line, breaking of axles, &c., we have nothing to do, as no electric apparatus would prevent these.

The great object in railway traffic is to have but one train on one section of the line at a time; and it seems to us that the existing apparatus is fully capable of giving all the information requisite for ascertaining the position of a train, so as to ensure absolute safety against this kind of preventible accident. Hence in England, at any rate, the introduction of the Baillehache system would entail a useless expenditure.

MESSRS. WINTER AND MUIRHEAD'S QUADRUPLEX IMPROVEMENTS.

We reproduce from the American *Journal of the Telegraph* the following letter, in which some improvements in quadruplex telegraphy which were described in our columns are stated to have been anticipated. It does not appear that any publication of the prior invention was made; so that the latter does not detract from any credit that may be due to Messrs. Winter and Muirhead as independent inventors of the improvements in question. We shall at a future period, should it be necessary, reproduce also the diagram referred to:—

"Chicago, Ills., Aug. 15.

"In the issue of *The Electrician* for July 26th, 1879, appears a letter setting forth the novelty and efficiency of certain quadruplex arrangements made by Messrs. Winter and Muirhead. Not knowing at what date these gentlemen placed their improvement on record, I beg leave to inclose for the inspection of your readers an original diagram of a similar relay system invented by myself and witnessed by Mr. C. H. Wilson, June 7th, 1877. You may apply to my arrangement the exact description applied in *The Electrician* to the Winter-Muirhead system, and it will be found to fit exactly, inasmuch as they are identical.

"'At the receiving station there is a polarised relay adjusted to break the local circuit when the current is plus and to complete it when the current becomes minus; a local sounder or

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other receiver connected with this relay records the depressions of key A. There is also in the main current *(circuit)* at the receiving station a double tongued relay which is used for completing the circuit of the sounder or receiver intended to respond to the movements of key B. This double relay *which forms an important feature* in our system of quadruplex is so arranged that, in order that the local circuit should be completed, it is necessary for both tongues to be against their respective contact points.

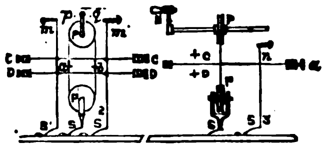
"'To accomplish this, either the tongues are insulated and the contact between tongue and tongue caused to be completed through the contact points, which in this case are connected electrically with each other, or the contact points are insulated and the contact between point and point is completed through the tongues, which in this latter case are of course connected together.'

"The action of the Winter-Muirhead relays under various operations of the keys and batteries having been described, said description being perfectly applicable to my system—the statement is made that 'on very long lines it may be necessary to use a local relay to work the recorder, the local circuit of this second relay being completed by the relay just described, but this will not be generally necessary;' and that 'with sounders there is an inconvenience which can be remedied by using an extra local relay to complete the circuit of the sounder.'

"The inconvenient absence of a uniform movement of the relay tongues under different strengths of current is the reason why I turned my attention from the double tongued relay to one of more simple construction and perfect operation. This improved relay, well and favourably known as the Jones' relay, is based on all carefully studied principles of induction and magnetism, intelligently treated by Fleeming Jenkin, F.R.SS., 'Electricity and Magnetism,' pages 74 and 284. It has already been generally adopted in the quadruplex apparatus used by the Western Union Telegraph Company. "F. W. JONES."

A NEW ELECTROMETER KEY.

Dr. O. J. LODGE read a communication at the British Association, describing a new key for electrometer work, the object of which is to supply a very conspicuous want among instruments for electrical research—namely, a commutating key for electrometers in which the insulation is so perfect that differences of high potentials may be tested without the very serious leakage which takes place in ordinary reversing keys, and without the errors introduced into measurements by reason of the great mass of their conducting



parts. In Dr. Lodge's instrument, which will be understood by reference to the above diagrams (which show the internal arrangements seen from the front and side respectively), the contact-pieces are simply four straight platinum wires *a*, *b*, C, and D, arranged in pairs at right angles to one another and supported and suspended by fine silk threads stretched vertically between a set of winding pins above, shown at *m*, *m*, *n*, and *n*, and stretching springs below marked S^1, S^2, and S^3. The middle pair of wires *a* and *b* are supported partly by the stretched silk thread *n* S^3 and partly by an endless silk cord which passes over two pulleys P and P^1, of which the upper can be rotated through a certain angle by the lever handle H, and the lower by being attached to a tension spring S keeps the vertical threads between the pulleys taut. Each of the wires is provided with a terminal screw by which it can be connected with other apparatus, and, from the construction of the instrument, it will be seen that by moving the handle H to the point *p* the wire *a* is brought into contact with the wire D, and the wire *b* is connected with C. Again, on moving the lever to the point *q*, *b* is brought against D and *a* into contact with C, so that a perfect reversing instrument is obtained with conductors of very small capacity, and having insulation as perfect as materials can afford. At the back of the little actuating lever is a little pin which springs into one of the three holes *p*, *q*, or H; when at *p* the contacts are the reverse of those when the lever is at *q*, and when at the intermediate position H, as shown in the figure, the contact-pieces are insulated from one another. It is only necessary to add that the instrument is enclosed in a metal case, which by being connected to earth acts as a very efficient shield against the effects of electrostatic induction as regards external objects.

At the conclusion of the paper Mr. JOHN PERRY, referring to experiments he had conducted in Japan, said that he had constructed with considerable difficulty a key for electrometer work in which leakage was provided against; he thought that Dr. Lodge had made a most valuable addition to the instruments of physical research, and he could say for his own part that had he had one of Dr. Lodge's instruments, he could have saved himself at least six months' labour.

STUDENTS' COLUMNS.

MR. JAMIESON'S LECTURES ON ELECTRICITY AND SUBMARINE TELEGRAPHY.

FIRST EXAMINATION PAPER (*Four Hours Allowed for Examination*).

N.B.—Answer any *ten*, but only *ten*, of the following *twenty* questions. The full value of marks obtainable is 1,000, and 800 marks must (at least) be obtained in order to get the prize. The value of each question is 100 marks.

1. What is the word *electricity* derived from? By whom and when were electrical effects first produced?

2. Mention the three distinct periods into which the history of electrical science naturally divides itself.

3. Give a brief account of Franklin's experiment with his kite. What objects had he in view? How was his kite constructed, and what were the materials he used?

4. Give five examples of how frictional or statical electricity may be generated.

5. What is the difference between a conductor and an insulator? Name *six* good *conductors* and *six* good *insulators*.

6. Explain clearly the different effects which moist air, dry heat, and flames have upon a highly-charged insulated body.

7. In what year and by whom were the terms *vitreous* and *resinous* electricity first adopted, and for what reason?

8. Give the modern terms, or those now used for vitreous and resinous electricity, and enunciate the laws of attraction and repulsion with regard to them.

9. Make a sketch of the electrical plate machine used at the lectures for generating frictional electricity.

10. Explain the electrical action of either the *plate* or the *cylindrical* frictional electrical machine.

11. Give a sectional sketch of the ordinary condenser used for submarine cable working. In what respects is it similar to the Leyden jar?

12. Upon what laws do the charge and discharge of condensers depend? Enunciate them.

13. Sketch in section an ordinary Daniell's cell. Mark the names of the several parts and ingredients, and give the chemical action which takes place when it is worked.

14. Draw Sir William Thomson's tray cell, explain the best plan of setting it up, and keeping it in good working order.

15. Give a section of Sir William Thomson's mirror galvanometer, and explain details.

16. State the laws of attraction and repulsion between parallel wires in which currents are passing in the same or opposite directions.

17. Give a cross section of the *Mouse Mill*, and explain its action in full.

18. Give a diagram of recorder (Sir William Thomson's) connections for one station, with condensers, keys, &c.

19. Give a section of the ordinary deep-sea type of submarine cable, name the parts, and explain briefly how it is manufactured.

20. Name the units of resistance, capacity, electromotive force, and current, and state *Ohm's law*.

ANDREW JAMIESON, C.E.

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HIPP'S ELECTRIC CLOCK FOR GIVING THE ASTRONOMICAL TIME AT GENEVA.*

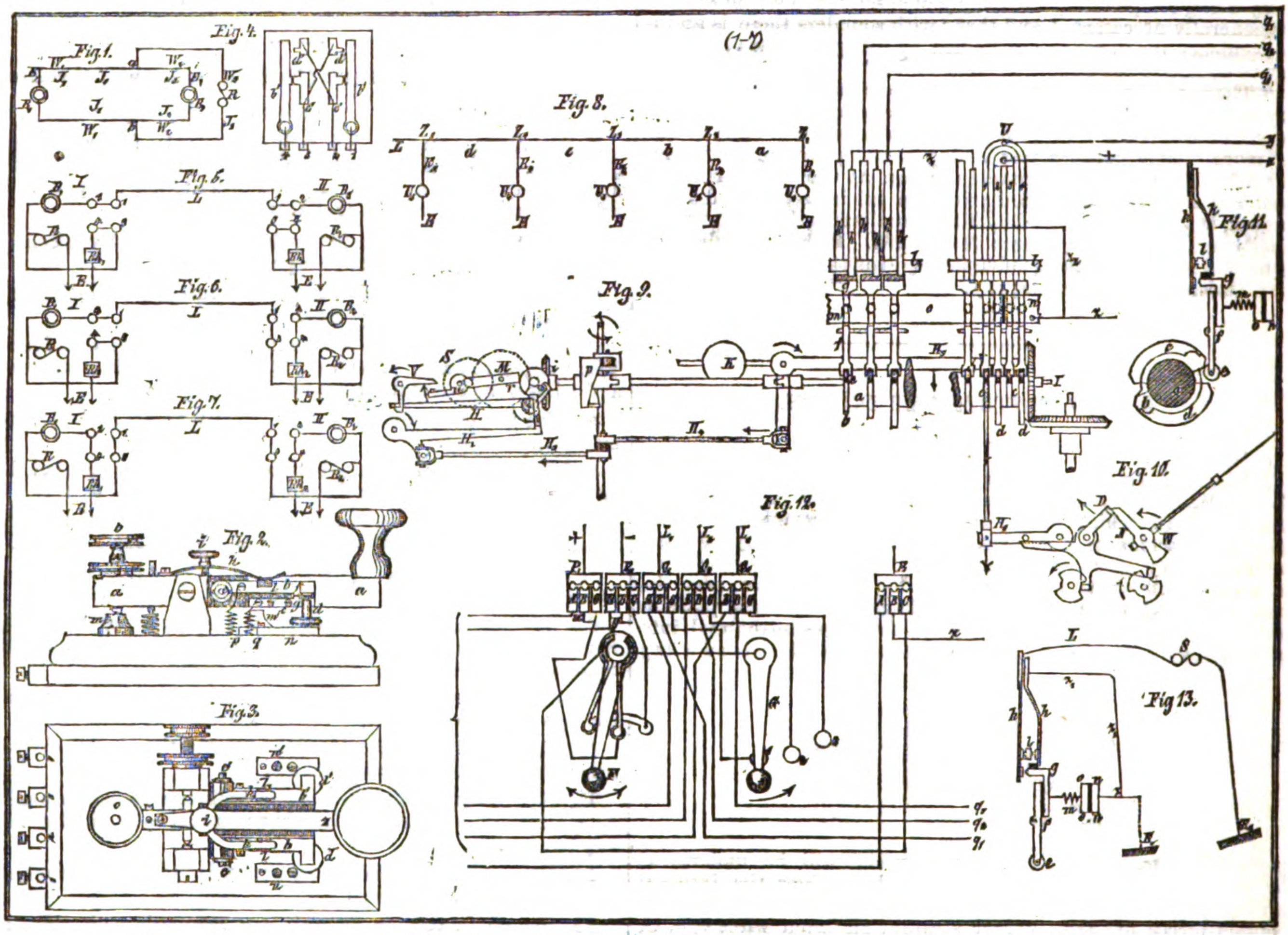
BY L. LOSSIER.

It is very important and desirable for horologers to be able easily to obtain the exact time. The regulators employed for that purpose are more or less exposed to considerable fluctuations, which hinder the regulation of ordinary clocks (watches), and render that of chronometers almost impossible. In order to bring about the possibility of obtaining the almost absolute exactness requisite for the latter, a number of the watchmakers of Geneva combined in 1873, and formed a plan for the electric communication of the exact time from the observatory to their factories. Then it became a question of giving one daily signal or several repeated ones. Some feared that a single signal would be difficult to catch, and that it would necessitate observation at some fixed hour of the day. The expense of the project appeared too great for the small number of those concerned, and the help of the town was therefore sought and a complete system of electric clocks was then resolved on; the civil engineer Rehfous was appointed to examine the matter and to ascertain the special requirements of the watchmakers, and in December, 1875, the town council decided upon adopting the plan which is now carried out.

The following conditions were imposed:—(1) That the clocks should work with certainty, and (2) exactness in the given time, which should have a mean variation of not more than one second, and a maximum variation of not more than two seconds from the exact time. For this purpose it was necessary to provide (1) two very accurate regulators, which, in case of need, might easily and quickly replace one another; (2) an exact and accurate comparison of these regulators with the astronomical observations; (3) batteries which should be constant and so arranged that the current being free from accidents and fluctuations should have always the same intensity; (4) carefully insulated wires; and (5) clocks working regularly and independently of one another, which should be as far as possible removed from atmospheric influences.

Dr. M. Hipp, Director of the Telegraph Factory at Neuenburg has solved the problem satisfactorily. The clocks are distributed over eight lines which radiate from the Town Hall, and which are traversed by the current one after another once in each minute. The direction of the currents following one another in the same line alternate, and the clocks themselves have polarised electro-magnets. Thus the clocks work with a very weak current; the number of movable parts is small; there are no springs, which are always exposed to fluctuations due to atmospheric and molecular changes; and the clocks are insensible to external shocks and concussions, and to atmospheric electricity.

The clocks in each line (as Hipp took especial care to do with his clocks) are so arranged that the portion of the current requisite for each one is conducted to it by a wire branching off from the line, and enters the earth behind the clock. The clocks are thus rendered independent one of the other, so that an interruption occurring in one clock has generally no influence upon the working of the others. The resistances in each clock must, however, be calculated exactly, if the current is to be equally strong in all the clocks. If from the end Z, of line L (Fig. 8) between the clocks U_1 and U_2, U_2 and U_3, &c., there lie lengths of line with the resistances *a*, *b*, &c., the clocks in succession must receive the additional resistances, R_1, R_2, &c., which may be calculated in the following manner:—



First of all, $R_1 = 0$. Further, if U_1 and U_2 are to receive equal proportions of the current, there must be equal resistances in both branches from the point of branching Z_2; hence R_2 must equal *a*. U_3 is to receive as much of the current as U_1 or U_2, and thus half as much as U_1 and U_2 together; hence, according to Ohm's law, from the point of branching Z_3 the resistance as far as U_3 must be twice as great as the resistance $r_2 = b + \frac{1}{2} a$ as far as U_2 and U_1; hence $R_3 = 2b + a$. The current for U_4 must amount to $\frac{1}{3}$ of the current which goes to U_3, U_2, and U_1 together; the combined resistance in the latter circuit, from the branching point is:—

$$r_3 = c + \frac{(2b+a)\left(b+\frac{1}{2}a\right)}{(2b+a+\left(b+\frac{1}{2}a\right)} = c + \frac{(2b+a)^2}{6b+3a} = c + \frac{1}{3}(2b+a);$$

consequently,

$$R_4 = 3r_3 = 3c + 2b + a$$

And, generally,

$$R_n = (n-1)k + R_n - 1,$$

if the conducting resistance *k* lies between U_n and $U_n - 1$.

* Translated from *Dingler's Polytechniche*.

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These resistances, however, cannot be calculated once for all, because *a*, *b*, *c*, &c., are variable, wherefore, also, the R's must be regulated from time to time; but the labour bestowed upon this is compensated by incontestible advantages as regards the arrangement of clocks in a circuit, namely, by the correct working of the clocks. The contact in the regulator must be certain; and hence it must be made sure with a known strength, but a considerable friction is thereby caused, which cannot be overcome by a regulating apparatus without disturbing the working of the regulator. Hipp has, therefore, separated the movement which makes the contact from that which moves the balance-wheel. During 59 seconds both movements are entirely independent one of another; in the 60th second they work upon one another by means of a very small falling lever, which produces only an imperceptible friction without disturbing the working of the regulator. The works of the balance-wheel consist of only two wheels, the balance-wheel S and the driving-wheel M (Fig. 9, plate 37). The latter does not turn upon a fixed axle, but hangs free between two pinions with which it is connected; the first pinion (in fig. 9, on the left) rests upon the axle of the balance-wheel, the other is in connection with the axle of the switch. The balance-wheel S is set in motion only by the weight of the driving-wheel M, which naturally changes its position, as its axle placed *r* round the axle of *u* the turning fork sinks; at the end of its course (in the sixtieth second) the left end of the fork *r*, by the raising of the horizontal arm of the angular lever V, sets free a small falling lever H, which, in falling at the same time, causes the lever H_2 to fall (which till then was hanging upon its half cut-out axle) whereby the latter acts upon a row of levers, H_3 to H_6 (Fig. 10) and removes the escapement of the movement or minute works. As these levers move in the directions indicated by the arrows, they turn the "sperklinke" D (hitherto lying before the arm N upon the axis of the fly-wheel) just far enough to liberate N. The minute works now make one revolution, which corresponds with an advance of the minute-hand of one minute. The switch, impelled by the two levelled wheels I of the movement, makes half a revolution, during which the current is sent successively into the separate lines. At the same time, the movement allows, by the bevelled wheel *i* (Fig. 9), the second pinion connected with the driving-wheel M of the works of the balance-wheel to make one turn, and this raises the driving-wheel as far as it sinks every minute. At the same time a pin on the one bevelled wheel *i* catches the lever H, and turns it round on its axle so far that it catches again the angular lever V; whilst the other levers, H from H_2 to H_6, are by the excentric *p*, with the assistance of the counter-poise K, brought back to their original position. The minute works are driven by a weight of (90lb.) 40 K. At first a wheel was employed as regulator for these works; but as the time was required to be exact to the fraction of a second, this proved insufficient, because the switch at one time made a revolution in fourteen seconds, at another in more or fewer. Hipp, therefore, replaced the wheel by a conical pendulum, which gave a surprising exactness, inasmuch as the resistances of the friction or the increase or diminution of the driving-weight produced exceedingly small variations in speed, which were measured by the "coincidence-pendulum," to be described presently. For correction and setting the right time two auxiliary pendulums are added.

Besides the principal regulator, there is an auxiliary regulator, which, although constructed on the same principle, is of an older and less perfect model. Both are constantly working, but only one sends the currents, viz., the principal regulator. But if the latter for any reason has to be stopped, the connections are, by means of the indicator, represented in Fig. 12, transferred from the principal to the auxiliary regulator, which now drives the clocks, until the principal regulater comes again into operation. From this transfer there results a certain slight inaccuracy, because the two synchronised regulators do not send the currents in quite the same manner; this, however, is of small consequence, because it occurs very seldom, and only in exceptional cases.

The positive and the negative pole of the battery are conducted to the rod P_1 and P_2 of the indicator, fig. 12; and from the rod Q_1, Q_2 &c., of the lines L_1, L_2, &c., radiate. (In Fig. 5, as in Fig. 9, not 8, but only three lines are represented, and the parts necessary for these.) In general, by stoppage between B_1 P_1 and B_1 P_2 the poles are, by means of wires *x* and *y*, conducted to the current reverser V (Fig. 9) of the switch in the principal regulator. In V the springs 1 and 3 make contact in the first minute; in the next 2 and 4, and so on. The rods Q_1, Q_2, &c., of the indicator are likewise stopped on B, and are, therefore, in connection with the springs *k*, by the wires q_1, q_2, &c.; lastly, the rod E, leading to the earth, is by the stoppage on B, connected by wire *z* with the rod *n*, and at the same time by 2, with the springs *h*. As we see in Fig. 11, upon the axis *a* of the switch for every spring *k* there rests a cog *b*, and these, one after another, by means of the small roller *e*, and of the lever turning around *f*, moor the piece of metal *g* (insulated from *f*) close to the spring *k*, and raise it from the rod *l*, whilst at the same time they allow the spring *h*, hitherto kept back by a piece of india rubber upon *g*, to place itself upon *l*; and thus in succession L_1, L_2, and L_3 over Q, B, *q*, *k*, *g*, and the springs *m*, are connected with the rod *o*, insulated from the rod *n*, whilst at the same time *n* over *z*, B and E remain constantly in connection with the earth. At the end lying to the right hand the axis *a* supports two pairs of longer cogs, *c* and *d*, placed opposite each other at an angle of about 80 degrees; at the first half-turn the cogs *c* lay their levers *g* upon the springs 1 and 3; at the next half-revolution the cogs *d* lay their levers *g* on springs 2 and 4; and as the levers *g* working on 1 and 2 are connected by their spiral springs with the rod *o*, the levers *g* working on 3 and 4 are, on the other hand, by their spiral springs, connected with the rod *n*, insulated from *o*, and as the axle *a* at every liberation of the movement (Fig. 10), *i.e.*, at the end of each minute, makes half a revolution, in the one position of *a* the current is conducted from the positive pole of the battery over *x* and 2 in U, and in the other position of *a* from the negative pole over *y* and 1 in U, to the plate *o* and in succession to the lines L_1, L_2, L_3, whilst in the first case the negative pole over *y* and 4 in U, and in the other (*i.e.*, in the next minute) the positive pole over *x* and 3, stands in connection with the plate *u* and through *z* with the earth E.

In order to prevent the sparks leaping over between *g* and *k* in the backward course from *g f e*, and the burning of the points of contact which would result from this, at the moment of the interruption of the current, a circuit complete in itself $k\,l\,h\,z_1\,z_2\,z\,E_1\,E_2\,S\,L\,k$ (Fig. 13) is established (through the spring *h*, now placing itself together with *k* on the rod *l*), in which circuit the electro-magnet S of the clock lying in the line L can give out the extra current. If, on the other hand, the lever *g* is pushed forward far enough from the cog to the spindle *a*, the contact between *k* and *l* is removed, and the battery-current must pass to the clock from the rod *o*, passing *m*, *g*, *k* into the line L and through the electro-magnet S.

By plugs upon the six rods of the indicator marked A, the battery-poles and the lines are attached to the auxiliary regulator by means of the six wires running out from the rods A. Lastly, a stoppage in the rod C connects the poles and the lines with the pendulum F, and conducts the current, always according to the position of the pendulum F, in one or the other direction without interruption, to that line L upon whose knob the crank G is placed. The comparison of the working with the mean time and the setting require much skill and care, as it is a question of sixtieths of a second. On this account the Town Hall is connected with the Observatory by a ninth telegraphic communication. In the Observatory there is a regulator (destined solely to give the astronomical time), with a movable contact, which at pleasure can be put into or out of operation. In the first case a small pin in the balance-wheel in the sixtieth second of each minute touches gently a small plate of platina, and sends out a current as a time-signal, which is received at the Town Hall by means of a "coincidence-pendulum;" this consists of the works of a clock without hour-hands (which here would be useless), but which beats 61 seconds per minute. At rest the pendulum is caught by the anchor of an electro-magnet; the current coming from the Observatory sets the pendulum free, and then the seconds are counted up till the moment when the pendulum beats together with the regulator. For instance, should this take place at the sixteenth second, the regulator is either $\frac{16}{60}$ of a second in advance, or $\frac{60-16}{60} = \frac{44}{60}$ behind. The correction itself is then made by means of the two auxiliary pendulums attached to the principal regulator, which are both regulated to the sixtieth of a second; thus just as many sixtieths of a second as the regulator is in advance or in arrear, just so many seconds the one or the other pendulum is allowed to go, and every swing of the same makes the regulator $\frac{1}{60}$ of a second in advance or in arrear.

Both Town Hall and Observatory are, moreover, furnished with complete (needle) telegraphs for speaking, with alarums, for which a special battery is employed. This telegraph is attached to the ninth line by means of an indicator, when the line is not connected with "coincidence-pendulum."

The following is the course of procedure. At noon the astronomer observes the variation of the clock of the Observatory, and corrects it by additional weights on the pendulum. At one o'clock the regulator comes to the Town Hall, announces himself, and asks the time; the astronomer answers, if he is ready. In this case he puts in operation the contact of his

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regulator, and now the signal is given once every minute for ten minutes, which is sufficient for the regulator to make the correction, and to control the exactness of the working. If he remark an unusual variation, which makes him suspect the existance of an error or irregularity, he informs the astronomer of it, and the latter examines his observations, in order to alter the results where necessary. One clock is placed in the office of the electric-time for each line for the control of the correct working. The clock in the eighth line has a similar "coincidence-pendulum," which makes it possible to observe how much this eighth clock is behind the right time, and what time the switch needs for one revolution; moreover, by it the working of the latter can be watched and corrected.

The batteries in use are carbon-zinc elements with a liquid (a solution of 3 parts of salammoniac and 1 part of common salt in 10 parts of water). The carbons are hollow cylinders of ·36 mètre in height. These batteries are powerful, have little resistance, which is important for branched currents, and remain in working order for a long time (about a year). They easily become polarised, but this is not detrimental, as the necessary current is of short duration. Four batteries are kept ready for use, each one of 10 elements. Only three of these batteries are actually at work, the fourth serving as a reserve. The batteries are filled and set at work at different times, so that the current may remain always about the same.

This arrangement of several parallel batteries, recommended by Hipp, is very advantageous, inasmuch as it guards against disturbances by the breaking of the glasses (otherwise rather frequent), of the zinc or other parts of the cells. The batteries stand in a cellar, in which the temperature does not vary very greatly summer or winter. In order that they may be examined, wires are conducted from them to an indicator in the neighbourhood of the regulators, so that by the insertion of stops, the intensity of the current of each battery singly, or of all together can be measured conveniently, and without interruption. This is done daily, and indicates when a battery needs to be renewed.

The lines for giving the time must, as far as possible, be of unvarying resistance, and insulated as well as they can be; the latter, in a town, with air-lines, is more difficult to carry out than it seems. After several unsuccessful experiments the use of porcelain and glass insulators has been given up entirely, because they are too fragile, and because, in the case of long-continued rains, the proportionately very strong current for the working of the clocks was so powerfully turned aside that several clocks stopped. Finally cast-iron bearers were chosen, which are insulated within the brackets by a glass sheath. The new lines thus constructed have been in working order since August, 1876, and fully answer all expectations.

The exactness of the time given by this plan is dependent only on the astronomical observations. The given time is, however, not, strictly speaking, the time of the meridian of the Observatory, since the communication follows in succession in the eight lines, and in the last is 14 seconds too late; however, the delay in each line is exactly the same. The comparisons need thus only to be made always with the same clock or one clock in the same line.

Ordinary electric clocks give only one leap per minute; for those persons who wish to have seconds, clocks are manufactured at Hipp's factory at Neuenburg, which resemble the control-clock inserted in the eighth line, and which advantageously replace a regulator.

HEINRICH'S ELECTRIC LIGHT REGULATOR.

On Wednesday evening a private trial of this apparatus took place at Sage's Commercial Buildings, 80, Gray's Inn-road, between the hours of 8 and 10 p.m. Amongst those who were present to witness the experiments were the Lord Lindsay, M.P.; W. Spottiswoode, F.R.S.; Mr. S. Wills, of the Commercial Iron Works, Shoreditch; Mr. E. Cox, of Lothbury; Mr. F. Flower, of 3, Piccadilly; and Mr. John Ashby, of Staines; all of which gentlemen take an interest in electric lighting, and appeared to be much gratified by the results obtained with the new lamp. This was suspended in the open air at a considerable elevation above the ground floor of the warehouse adjoining the London Sand Blast Works, where the observers were stationed. The illumination obtained was remarkably free from any shadow cast by the apparatus itself; and the use of a large tin plate reflector softened considerably the shadows of objects upon the ground, which, when one light is used alone, are generally very sharp, owing to the absence of penumbra. The dynamo-machine used was one of Siemens', of from 1,200 to 1,800 candle power. The light obtained was one that would be suitable for railway stations, churches, or large public halls. An electro-magnetic motor, invented by Mr. Heinrich, was also shown; this was worked at a speed of 1,600 revolutions per minute, by means of a Gramme machine, working at 850 revolutions; the revolving armature of the motor weighing upwards of 40lb. The loss of power in this motor, worked by a dynamo-machine at a distance of 60 yards, was stated to be 25 per cent. Amongst the other objects of interest shown was an adjustable brush holder, for collecting the currents from dynamo machines; any required amount of pressure being applied, and permanently maintained, by means of a spring, which allows of the contact being at any time instantly broken.

INTERNATIONAL METEOROLOGY.

We have received a copy of a very remarkable printed document, namely, the *Monthly Weather Review*, embodying the observations of the General Weather Service of the United States during July last, as compiled by Brigadier General Albert J. Myer, Chief Signal Officer. The *Review* is accompanied by seven weather maps, four of which have an international character; the remaining three relating to the United States only. The printed matter extends over 16 pages, which are devoted to observations on barometric pressure, international meteorology, temperature of the air, precipitation, relative humidity, winds' verifications of forecasts, navigation, temperature of water atmospheric electricity, optical phenomena, and miscellaneous phenomena. We notice this document, not only because some of the articles are of special interest from an electrical point of view, but also because it illustrates what can be done in scientific meteorology at the present day, through the instrumentality of our lines of telegraph, and because in certain directions it offers an example which other nations might do well to follow.

Under the heading of International Meteorology, and in reference to the world weather charts, or international weather maps above referred to, it is explained that it has been the plan of these charts that they should be based upon observations taken simultaneously by day and at night on land and at sea. The observations to be those of the barometer, thermometer, weather, &c., taken everywhere on the globe at the same fixed instant of physical time—That is, for example, observations so arranged that those at Washington, St. Petersburg, Constantinople, &c., are taken not at the same hours of local or clock time at those cities—for they would not then be taken at the same moment, but so arranged that the readers or observers are actually all reading and recording at one and at the same moment when the readings and records are being made at every other station, and so for all places. The atmosphere over any extent of the earth can thus be viewed as a whole, and at once before any movements in it are possible. The resulting charts give a true synopsis—in effect a photograph of the atmosphere and its conditions at the instant. Such observations are known as Simultaneous Observations. They are characteristic of the work of the office of the Chief Signal Officer of the War Department in the United States. And, under the head of Verifications, we are informed that the detailed comparison of the tri-daily weather indications for June with the telegraphic reports for the succeeding twenty-four hours, shows the general percentage of omissions to be 1.41 per cent., and of verifications to be 85.1 per cent. The percentages for the four elements have been, Weather, 97.3; Direction of the Wind, 87.0; Temperature, 82.4; Barometer, 87.3. The percentages of verifications by geographical districts have been: New England, 83.9; Middle States, 89.1; South Atlantic States, 82.3; East Gulf States, 80.8; West Gulf States, 82.5; Lower Lake region, 87.7; Upper Lake region, 86.3; Tennessee and the Ohio valley, 82.4; Upper Mississippi valley, 87.6; Lower Missouri valley, 85.0; Northern Pacific coast region, 91.7; Central Pacific coast region, 100; Southern Pacific coast region, 100. Of the 3,813 predictions that have been made, 149, or 3.91 per cent., are considered to have entirely failed; 116, or 3.04 per cent., were one-fourth verified; 423, or 11.09 per cent., were one-half verified; 457, or 11.99 per cent., were three-fourths verified; 2,614, or 68.55 per cent., were fully verified, so far as can be judged from the tri-daily weather maps. From his report it would appear that the art of drawing up meteorological forecasts has greatly progressed since poor Admiral Fitzroy passed from amongst us The observations included under the head of Atmospheric Electricity do not appear to be so extended as those made in other departments of meteorology; and, as they are limited to the area of the United States, we shall forbear to quote them. We have, however, said sufficient to show that the *Monthly Weather Review* is of great interest to those who study the results obtained by the use of the telegraph in obtaining simultaneous meteorological observations.

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COMPLETION OF SOUTH AFRICAN CABLE LINE.

IMPORTANT TELEGRAM.

A telegram from Aden, received by the chairman of the Eastern Telegraph Company, says :—" Captain Manning, of the steamer Seine, arrived here from Mozambique, reports that the latest authentic telegraphic news from Natal when he left Mozambique on September 1, reported that King Cetywayo was captured on August 28, in the south-eastern extremity of Zululand, on the confines of the Amatonga country.

" The South African cable was successfully completed between Natal and Mozambique on August 23."

(REUTER'S TELEGRAM.)

CAPE TOWN, AUG. 29 (*viâ* Aden).

Major Richard Marter, with a detachment of the 1st Dragoon Guards, captured Cetywayo yesterday.

A BALL BY THE ELECTRIC LIGHT.

The question of the adaptation of the electric light for houses and the interior of buildings generally has recently been decided in an agreeable and practical manner, and with results of the most satisfactory kind. On the 1st inst., at the invitation of the engineers of the Milford Dock Company and the engineers of the contractor, about fifty of the *élite* of the neighbourhood of Milford assembled at the Lord Nelson Hotel, Milford Haven, and a ball was held in the large room of the hotel. Many of the ladies were apprehensive lest the intensity of the light might have an unpleasing effect, and it was with some trepidation that they entered the room. They were agreeably surprised to find that their fears were groundless, and the unanimous opinion of all present was that the pleasures of the evening were greatly enhanced by the exhibition of this beautiful light. The British Electric Light Company may be congratulated on the brilliant success of their light, and the warm thanks of every one present was ungrudgingly given to Mr. Lake, the contractor to the company, who freely lent the machinery and all necessary appliances for the occasion.

The distance of the engine and Gramme machine from the room was at least 500 yards. The light was shaded with an inverted " bonnet," placed underneath it, so as to prevent the rays from being thrown directly downwards; the reflection coming from the ceiling.

The arrangement was very effective, and, with the exception of a few minutes at about 12 o'clock to change the carbons, the light burned steadily until five o'clock in the morning. There was no perceptible heat during any part of the evening, and we can confidently recommend any one about to give a ball, if situated within connecting distance of the electric light, to incur the necessary expense to produce such a pleasing and brilliant result.

The electric engine was supplied by the British Electric Light Company, and has a special "governor," which keeps the engine constantly at 800 revolutions, a speed which it never exceeds; consequently there is great steadiness of light, and an absence of the flickering observable in many electric lights. The engine drives two Gramme machines, and has been placed by the contractor of the docks, Mr. Lake, on the dockhead to work two lights for the purpose of getting in the dock sills, &c., and will be in practical operation for this purpose henceforth. The arrangement for lighting deserves some description. The stern of the Great Eastern steamship is within 150 feet of the entrance to the dock, and both lights travel on a wire rope fixed on the stern of the vessel; the two supporting masts are on either side of the entrance. Thus the light can travel to any point of the work as required. By the application of two lights in this manner, and their being able to travel from point to point, standing one on either side of the work in progress, all shadow is avoided, and the men are able to work by night as well as by day.

The dock is rapidly approaching completion, and it will be the largest graving dock in the world, having sufficient depth to accommodate the Great Eastern when loaded, there being 34 feet of water even on the sills at ordinary spring tides.

Connected with this dock is a smaller graving dock of 260 feet, and a floating dock measuring 60 acres. The graving dock can be entered either from the floating dock or from the Haven, and is intended to be used as a floating dock when not required as a graving dock for the Great Eastern or any of the great ironclads. The American trade, which will, no doubt, be the principal trade of this port, will receive a fresh impetus when these works are completed, and, if we may take as an earnest the energetic manner in which the works are being pushed by the contractors, we shall certainly see them ready and fit for occupation in the early part of next year. The completion of these works will, no doubt, give to Milford Haven those facilities for its due development that all authorities concur in advocating. The whole of South Wales must of necessity receive a large share of the benefits that will accrue to the Dock Company and the town of Milford.

The Great Western Railway will, doubtless, secure a large increase of traffic, and that portion of their South Wales lines which has hitherto produced meagre results may show a very different result after the first year's working of these docks. It has been rumoured, from time to time, that Her Majesty Government would subscribe to the proper construction of the large graving dock, on national grounds, by reason of its great importance as a refuge and refitting station for our largest ironclads.

BRITISH ASSOCIATION.

ELECTRICITY AS A MOTIVE POWER.*

(CONCLUDED FROM PAGE 204.)

At present I am concerned with the pounds, shillings, and pence question, which has more than usual weight in these days of slack trade. Well, then, assume the cost of gas used for lighting the large buildings, factories, and the streets of Sheffield can be halved; also, that where it is used for heating purposes, the expense can also be halved, by substituting electric currents generated by very large steam engines at certain points, and by turbines driven by falling water out of the town; then you would save per year about £45,000. Suppose also that the cost of producing motive power can, in the same way, also be halved, this represents an annual saving of something like £60,000. In reality, I believe this last economy would be larger, since not only could power be produced so much more economically than by small steam engines or even by a large engine, when a large proportion of its power is, as now, wasted in driving the shafting alone in your factories; but, in addition, much handwork could be economically replaced by machine work. And, lastly, suppose the consumption of coal in Sheffield for heating your metals and for heating your houses could also be halved, then there is another saving of about £300,000 a year—or, altogether, the annual saving that might be produced in this town alone, by substituting electricity for coal, would be something like the large sum of £400,000.

It is hardly necessary for me to point out to you how much capital a company would be willing to advance for such a comparatively certain profit yearly, or whether a large portion of this saving could not be effected by expending only a portion of this capital.

But I think I hear you saying this is all very nice, but there must be certainly something wrong in it all; is it likely that Sheffield could save £400,000 a year by merely using machines to whirl round coils of wire to produce electric currents?

If that be the impression this lecture is producing in your minds, and I can hardly expect the more thoughtful to at once accept the truth of so novel a reform as I am here advocating this evening, and which probably you are listening to for the first time, allow me to adduce the following arguments to prove that, although the reform is startling, it may still be sound:—

Imagine the cost of cutlery and plated goods to remain the same as at present, but all machinery to be removed from Sheffield, then what an enormous loss would accrue to the town from everything having to be done by hand labour. The saving, then, I am showing you how to obtain, enormous though it may be, is still small when compared with the gain that the introduction of machinery during the last hundred years has effected for this town.

Or, again, it may be objected that I talk of using water power at the hill side to drive turbines. But this water cannot come afterwards into Sheffield for drinking and other purposes, because to do work it must lose head. We must, therefore, waste at the source all the water we use for power. But has the Sheffield Water Works any water that can be thus dispensed with in the town? Assuredly, thanks to the energy and perseverance with which the Sheffield Water Works Company have conducted their operations, there is always in hand a very large stock of water. For instance, at present there is in the reservoirs at Redmires, Rivelin, Agden, Strines, &c., enough to last the town for six months if not another drop of rain falls (which is a far more unlikely occurrence than that every Sheffield manufacturer will speedily adopt electricity), and when the reservoirs at Damflask and Dale Dyke, now completed but not yet in use, are employed, there will be at any time, I understand, a year's supply of water in the reservoirs, even if the consumption of Sheffield somewhat increases.

Bearing this in mind, as well as the fact that the company has also power to construct two other reservoirs in the Ewden Valley, it will be seen that there is no lack of water, and I am sure there will be no lack of willingness on the part of the company to allow water at the source to be used, especially when such an arrangement can be made remunerative both to themselves and to the manufacturers.

As an example of what water power can do, we will now cut a 2-inch board with a circular saw driven by an electric current produced by the water motor in the yard of the Water Company, and conveyed to this hall by the wires crossing the streets.

So much for what may be done by electricity in producing motive power. Now, let us consider what has been actually done. Last year two French engineers, MM. Chrétien and Felix, at Sermaize (Marne), actually ploughed fields by electricity, the electric current being produced by two dynamo-electric machines, of a form invented by M. Gramme, and shown in the diagrams on the walls. These machines were usually worked with a steam engine at some convenient place three or four hundred yards away in an adjoining road, and the electromotors were also two Gramme machines, one on each side of the field, with their coils revolving, of course, backwards. Through one of these the electric current was sent alternately, so that motion was given to one or other of two large windlasses, one on each of the waggons containing the electromotors. In this way the plough, which could be used going in either direction, was first pulled across the field, making a furrow, and then back again, making another parallel furrow.

A photograph, taken on the spot, of one of the complete Gramme electromotors, with its windlass and waggon, together with the double-acting plough, will now be projected on to the screen.

A second photograph is now projected on to the screen of M. Chrétien's electric crane for unloading boats. This also has been successfully employed for several months at Sermaize, in the harbour there, and it is considered that a saving of about 30 per cent. has been effected of the expense formerly incurred for unloading the sugar barrels out of the boats.

If electricity were produced in large quantities at certain centres, then one difficulty that would, of course, be met with would be that of distributing it properly, since, just as in the case of water or gas, if a large branch pipe in a main be suddenly opened, then the supply going on to the other branch pipes in the same main will be diminished, a result causing serious inconvenience in the case of electric lighting. But just as automatic

* A Discourse delivered to the Working Men of Sheffield, August 23rd, 1879, by Prof. W. E. Ayrton.

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governors have been devised for water and gas to keep the supply constant, so automatic "electric current regulators" have been devised by M. Hospitalier and by Dr. Siemens to keep the current constant. One of those invented by Dr. Siemens is on the table before you, and the general principle of its construction is easily understood. As the current passes through the regulator it heats a certain very thin ribbon of steel, which consequently expands. The effect of this expansion is to introduce coils of wire into the circuit, the extra resistance of which diminishes the strength of the current. Consequently, the stronger is the current the more is it automatically resisted, and the weaker it becomes the less is it resisted, and so it remains practically constant at any desired strength for which the regulator is previously adjusted.

The peculiar advantage of Dr. Siemens' regulator is its rapidity of action, since, as the strip of steel has very little mass and a large radiating surface, its temperature alters very rapidly for a small change in the amount of heat produced in it per second, that is, for a small change on the current flowing through it.

But our electric current would be affected in another way. While the supply of energy and heat required in a town is fairly constant from day to day, the velocity of water on hill streams is great after floods, and small in dry weather. Must we, then, have a sufficient supply of dynamo machines, so that even in a drought we can transmit, electrically, sufficient power? if so, in times of rain, like the present, the waste of water power would have to be enormous; or is it possible, in any way, cheaply, to store up electric energy during an abundance, and use it during a scarcity? Assuredly, cannot we decompose acidulated water producing oxygen and hydrogen, an operation which experiment has shown will go on quite as easily when the gases produced are under enormous pressure, and occupy very little space, as when the gases are only under the pressure of the atmosphere, as they are in this voltameter from which you observe they are coming off as I pass the current through it? In these two very thick iron bottles I have stored up, under enormous pressure, some of this oxygen and hydrogen, and we will liberate a little of the bottled up energy, producing, as you see, this bright oxy-hydrogen light.

Now, assume the pressure of the gases in these bottles is only thirty times as much as the ordinary atmospheric pressure, then the energy given out by the hydrogen contained in one of these bottles, only a square foot inside, combining with the compressed oxygen, in another bottle, having its internal capacity only half a square foot, would be no less than 110 million foot pounds, or about the same as 60 horse-power developed for one hour, or one horse-power developed for two days and a half.

Decomposing acidulated water under great pressure by means of the electric current not only, then, enables us to store up electric energy, but to store it up in an extremely compact way.

But is there no other side to this question? We are, it is true, a commercial people, but do we not still love our hills and our fields? There was a time when the cutler of now black, grimy Sheffield was very fleet of foot in following the chase. There was a time when "Not only in the villages around old Sheffield," so says the history of Hallamshire, "were the file makers' shops or the smithy to be seen, with the apprentices at work; but even on the hill-side in the open country, at the end of the barn would be the cutler's shed, whilst in the valley below, by the river, was the grinding wheel ready to sharpen the tools that had been manufactured."

And why not now? Why should not that mountain air that has given you workmen of Hallamshire in past times your sinew, your independence of character, blow over your grindstone now? Why should not division of labour be carried to its end and power brought to you instead of you to the power? Let us hope, then, that in the next century electricity may undo whatever harm steam during the last century may have done, and that the future workman of Sheffield will, instead of breathing the necessarily impure air of crowded factories, find himself again on the hill side, but with electric energy laid on at his command.

Time will not allow to tell you more. Some of my ideas regarding electric transmission of energy you have heard; and whether you think these ideas are right, or whether you think them wrong, I venture to hope they may be regarded as worthy of careful consideration, for let it not be said that you, that I, that any of the workers of Great Britain, are allowing by a disregard of scientific principles, are allowing by a neglect of technical education, England's far famed pre-eminence to pass away; let rather our grandchildren, as did our grandfathers, hear that in all that is right England takes the lead; and when we find we can no longer maintain that superiority by the abundance of our coal, then let us maintain it by the abundance of our knowledge.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

Report of the directors for the half year ending 30th June, 1879, to be presented at the general meeting of shareholders to be held on Tuesday, the 30th September, 1879. The accounts for the half year ending 30th June, 1879, show a balance to the credit of profit and loss of £3,445 18s. 3d. The traffic receipts for the half year are £545 17s. 10d. in excess of those for the corresponding half year of 1878. This result has been attained in the absence of any improvement in business in Spain. The company's submarine cables continue to work perfectly, and remain in the same high electrical state as heretofore. The dividend on the 10 per cent. Preference Shares, which it is proposed to pay on 1st October, will absorb £2,921 10s., leaving £524 8s. 3d. Of this sum the directors recommend that £500 be added to the reserve fund, which will then amount to £2,200, after which there will remain a balance of £24 8s. 3d. to be carried forward.

RECENT PATENTS.

58. Galvanic Cells and Batteries, *W. Erck.—Dated 6th January, 1879.* 6*d.*

The cell is of lead in the form of a long, narrow and shallow trough, the sides of which are lined with carbon plates round which the lead has been cast. Into the space between the carbon plates is introduced a piece of rolled zinc. The exciting solution consisting of ordinary bichromate enters at one end of the trough and is removed at the other end, thus rendering the action of the cell constant. In a second arrangement circular discs of zinc and carbon are mounted alternately upon a horizontal revolving axis, and each pair connected together by a metal tube. The axis can be lowered so as to immerse the discs in separate cells placed beneath them. According to a third arrangement plates of zinc and carbon are suspended to a frame free to swing in a plane parallel to the planes of the plates, and capable of being lowered to immerse the plates into separate cells beneath them. So as to dispense with separate cells, small carbon and zinc plates are placed so close together as to support between them by capillary attraction a film of the exciting solution, which is changed from time to time by a drop falling between the plates.

60. Telephonic Apparatus.—*J. Imray.—Dated 6th January, 1879.—(A communication.)—(Not proceeded with.)* 2*d.*

In order to increase the delicacy of telephonic instruments in which the vibrating plate carries a piece of carbon, on which bears the end of another pivotted piece of carbon pressed against the former by a spring, the pivotted piece of carbon is balanced on its centre, and one arm is lightly pressed against the carbon on the plate by a spring formed of paper or thin card bent to a U form. For the receiving instrument it is preferred to employ as its vibrating diaphragm a piece of thin tin plate placed as close as possible without contact to the pole of the magnet.

81. Electric Lamps, *H. W. Hedges.—Dated 8th January, 1879.* 6*d.*

The guide for one carbon is mounted on a transverse axis, so that it can rock, and a spring presses it in the direction to cause its lower end to approach the other carbon. The armature of an electro-magnet is connected to this guide, and the coil of the magnet is in the circuit of the carbons, so that when a strong current passes through the coil the armature is attracted in opposition to the spring, and one carbon thus withdrawn from the other.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Sept. 17.		Business Done Week Ending Sept. 17. Highest.	Lowest.
Anglo-American Ordinary	53¼,	¾	53⅜	53
Do. "A"	27¼,	¾	27⅝	26¾
Do. "B"	82,	½	82½	82⅛
Brazilian	6¾,	7	7	6⅞
Cuba	7¼,	¾	7⅛	7⅛
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11½,	¾	—	—
Direct United States	10¼,	½	10⅛	10⅛
Eastern	7¾,	8	8	7⅞
Do. Six per Cent. Debenture	104,	107	106	106
Do. Five per Cent. do	101,	103	—	—
Do. Six per Cent. Preference	11 15-16, 12 1-16		—	—
Eastern Extension	7¾,	8	7 15-16	7⅛
Do. Six per Cent. Deb.	105,	108	107½	107⅛
German Union	7¼,	8	—	—
Globe Telegraph and Trust	4¾,	5	5	4
Do. Six per Cent. Preference	11 3-16, 5-16		11¼	11⅛
Great Northern	8¾,	½	8⅝	8⅝
Indo-European	21,	22	—	—
Mediterranean Extension	2½,	3	2¼	2⅛
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9,	10	—	—
Submarine	220,	225	—	—
West India and Panama	1⅛,	⅜	1 5-16	1¼
Do. Six per Cent. Preference	7¼,	⅝	7 7-16	7⅜
Western and Brazilian	2¾,	3¼	3⅛	2⅞
West. Union Seven per Ct. 1st Mt.	120,	125	—	—
Do. Six per Cent. Sterling	104,	106	—	—

TRAFFIC RECEIPTS FOR AUGUST, 1879.

Companies.	Aug. 1879.	Aug. 1878.	Incrse.	Decrse.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,300	2,569	—	269
Direct Spanish Telegraph Company	980	879	101	—
Direct United States Telegraph Company	17,100	—	—	—
Eastern Telegraph Company	36,257	35,889	368	—
Eastern Extension Telegraph Company	26,342	24,870	1,372	—
Great Northern Telegraph Company	16,800	—	—	—
Submarine Telegraph Company	10,790	10,152	638	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—

ELECTRICAL AND SCIENTIFIC APPARATUS.—WHOLESALE MANUFACTURERS OF ELECTRIC BELLS.—Our new metallic base Electric Bell and Constant Battery Indicators and Telephone Switches. Induction Coils of highest finish; Terminals, Carbons, and all materials. Silver and Nickel Plating and Gilding. Instruments made, repaired, or altered on the premises. Illustrated Electric Bell list free. Complete catalogue two stamps. Special quotations to the trade.—DALE and CRAMPTON, Electricians and Opticians, 4, Little Britain, London, E.C.

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NOTES.

Octoplex.—Professor Klinkerfues is said to have perfected another octoplex apparatus. We fear the professor is about fifty years too early, and that he will not succeed in superseding Quadruplex. By the end of the century we shall have a "plex" represented by 2^n, n being at present the unknown quantity.

Telegraphy in Java, &c.—There exists at present in Netherlands-India, ninety offices, of which twenty-three are post offices only, three telegraph offices only, and sixty-four both post and telegraph offices. During the year 1879 the Government propose opening ten new post and telegraph offices in Java, and two on the West Coast of Sumatra.

Telegraph Wire.—The directors of the Edison Telephone Company of London (Limited) invite tenders for one or more wires connecting the centre of Manchester with each of the following towns:—Bolton-le-Moors, Bury, Rochdale, Middleton, Oldham, Ashton, Stalybridge, Stockport; also tenders for 1,000 separate wires, averaging a quarter of a mile, 500 to centre in Manchester, and the other 500 to centre in the other towns above mentioned. Address the Manager, Edison Telephone Company of London (Limited). Interim address, 36, Pall Mall, Manchester.

The Tar Colours and the Electric Light.—Dr. Grieff contends that, even supposing the gas manufacture should ultimately be abandoned, the tar colours could be prepared from the residues left on rectifying the petroleum of the regions of the Caspian. These are estimated at 120,000,000 kilos. yearly, and are ten times richer in benzol and five times richer in anthracene than is coal tar. The American petroleum has not yet been examined from this point of view, but it will probably also prove to be a rich source of aromatic compounds.—*Die Chemische Industrie.*

The Telephone at Wolverhampton.—Arrangements are in progress which it is believed will result in the establishing of a telephonic exchange which shall be applicable to the requirements not of this town only but also of most of the surrounding towns. At present the only firms who are utilising the invention are Messrs. Ironmonger and Mr. Henry J. Denton. Messrs. Ironmonger have it in work between their shop in Victoria-street and their rope and twine and mat works in Brickkiln-street, a distance of three-quarters of a mile; and Mr. Denton has it in operation between his show room in Snow-hill and his agricultural implement works in Mark-street.

Glasgow.—St. Enoch Station Lighted by Electricity.—Last week experiments were made with the electric light in St. Enoch's Station with the view of testing its efficiency for lighting that place. Four lights were used, the machines being Gramme's, and the arrangements were carried out by Mr. Joshua Horton, agent for the British Electric Light Company. The lights were placed on girders in the corners, 30ft. or 40ft. from the platform, and the whole station was illuminated by a brilliant white light resembling a clear moonlight, which completely obscured that thrown out by the rows of gas lamps at present in use. The result was considered highly satisfactory. The experiments are to be continued for fourteen nights, and if the results are considered sufficiently good to warrant it the electric lights will be permanently adopted in the place of gas. Most of the directors of the Glasgow and South Western Railway Company and some members of the Midland board were present to witness the experiments, which were continued till nearly midnight.

Telephone Exchanges.—The following companies have been registered for the purpose of introducing the telephonic exchange system into this country:—*General Telephone Company (Limited),* capital £2,100, in shares of £5, and 100 founders' shares of £1, formed to manufacture, sell, work, rent, maintain, import and export, and generally deal in, telephones and telegraph instruments and apparatus connected therewith, to construct telegraph or telephone lines and cables, and establish agencies at home and abroad. The subscribers (who take one share each) are: General Cavanagh, Long Ditton; Colonel C. F. Surkes, Long Ditton; W. I. Lesanteur, Blackheath; G. W. Macboyde, Acton; J. Battus, 4, Austin Friars; C. Wollaston, Chepstow Place; A. Scott, 14, Elgin-crescent. *West Riding Telephone Exchange Company (Limited),* capital, £15,000, in shares of £5, formed to establish and carry on at Halifax, Bradford, Leeds, Huddersfield, &c., the system of telephone exchange now used in America, and being established in London, Manchester, and Liverpool; to erect, supply, and maintain all necessary wires and apparatus. The subscribers are: J. H. Whadcoat, Halifax, 3; M. H. Smith, Halifax, 3; J. Allen, Lightcliffe, 3; C. Bath, Halifax, 1; A. Ramsden, Kingston, 3; A. H. Hill, Halifax, 1; R. J. Kues, Halifax, 1.

Electricity applied to Bee-rearing.—A correspondent of the *Deutsche Presse* describes a method which he has adopted with success of overcoming the obstacles frequently presented to the rearer of bees by the self-will of those interesting and profitable insects. This is no other than giving them an electric shock. Every one interested in bees knows the difficulties and dangers involved in hiving a swarm. One is often seen on a hot day in June in the top branches of a tree not to be climbed, and another in some inaccessible place seems to be preparing to set out on its wanderings. If the beemaster venture to approach, all his dexterity and experience will often not prevent him from being seriously stung. There are, indeed, several cases on record of death supervening from the stings inflicted on such occasions. Herr Freiwith, the correspondent referred to, hit upon the idea of employing the electric force to stupify the bees. Trials on large and small clusters, and even on single insects, answered perfectly; the bees coming in contact with the conducting wires fell stunned and motionless to the ground. They were then sorted and marked, according to the strength of the current applied. The time required for their recovery, varying from ten minutes to eight hours, was proportionate to the strength of the shock, but all came out of their trance safe and sound. Encouraged by the result of this experiment, Herr Freiwith resolved to try it on a larger scale, namely, on bees in the hive. To this end he introduced the ends of two conducting wires into a fully occupied honeycomb, and turned on the current for a moment; the bees soon lay on the ground, and it was half an hour before they resumed activity. Herr Freiwith then constructed an apparatus in a small box, 6 inches each way, which, similar to a cartridge pouch, he wore with a strap round his body.

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The two wires of the apparatus were, when required to be used, fastened to rods of a suitable length, the wires of course always projecting over the ends of the rods. These ends were then applied to the swarm, a knob similar to that employed for a room telegraph being attached to the apparatus, that the current might be turned on at the proper time. Every one is, of course, not skilful enough to construct such an apparatus, though none are precluded from doing so, as Herr Freiwith has not patented it.

Electric Railway Station Indicator.—Railway passengers will hail with satisfaction an invention calculated to add greatly to their convenience and comfort (which has just been provisionally patented by Mr. F. M. Rogers, engineer, of 29, Moorgate Station-buildings, London), by which they may know with certainty the station the train is about to enter. The means by which this is accomplished are very simple. In each compartment there is a dial resembling the face of a clock, upon which is painted the names of the stations on the route. A hand or pointer connected with an electrical arrangement being caused to move round the dial when a current passes through the instrument, which current is automatically sent in this way:—Upon the under side of the step board of the first carriage composing the train is pivoted a small arm connected with a battery or other source of electricity, and as the train enters the station this arm strikes against a peg inserted under the edge of the platform. The arm is thus pressed back, and a current is sent through the wire and indicators, causing the pointers to show the station reached. The arrangement described is admirably adapted for the metropolitan lines, where the carriages are permanently coupled, and constantly travel the same road. Where carriages are separated, and for long journeys, a modification is necessary. As the proposed system is simple in action, and inexpensive in application, there appears to be no reason why it should not soon come into extensive use. The name of the station being shown in the compartment of the railway carriage, it is to be hoped that ere long the indistinct calling of porters, and the confusion and uncertainty frequently witnessed at stations, may become things of the past.

The Electric Telegraph in Norway.—The first line of telegraph in Norway, we learn from *l'Electricité*, was opened in 1854, with an extent of only 35 kilomètres. In the quarter of a century which has since elapsed all parts of the country (which measured 316,000 square kilomètres) have been covered by the telegraph system. The number of towns and large villages is somewhat small; thus, there are only 227 telegraph offices, and these are nearly all situated in different towns. Christiania is the only city which possesses more than one. One hundred and three of the offices belong to railways, and are worked mostly with the needle telegraph; but they are open for the service of individuals. The Government officers are not all constantly open; 16 are open only during the herring and cod fishery season, and are organised exclusively to facilitate that industry, by warning the arrival of fish. Parliament has a special telegraph office during session. The admission of females into the telegraph service has been the signal of a social revolution, and they have since been admitted into Government schools, business houses, &c. Though the salaries in the telegraph service are not very high, Norway being a poor country, most of the *employés* belong to the intelligent and educated class, and have studied at the University. The total effective force consists of 450 persons —one director, one surveyor, 11 inspectors, 264 male and 88 female operators, the remainder being students or subaltern *employés*. Two *employés* in the service have the honour to be sent to Parliament, so that the interests of the telegraphic profession are never forgotten, and the service receives all the improvements approved by science and compatible with the resources of a small country the population of which does not amount to two million inhabitants. The Observatory has a line connecting it with the telegraph system, so that once a month all the clocks are regulated by those of Christiania, and the prevision of the weather takes place regularly. None of the communes receiving the daily announcements are required to pay anything. Candidates for the telegraph service must understand English, German, and French. There is a telegraphic school, where they receive professional instruction after admission to the service. They must have a certificate from the director of the school in order to enter on active duty. The sexes are not separated in the offices, and numerous marriages are the result.

The Telephone at Saltaire.—The offices of Sir Titus Salt, Bart., Sons and Co., at Saltaire, and Milner Field, the residence of Mr. Titus Salt, have been recently connected by telephone with Square Congregational Chapel, Halifax, and sermons were preached in the morning and evening at that chapel by the Rev. Dr. Mellor. The Crossley Patent Microphone, which is fixed in the pulpit of Square Chapel, was connected through Messrs. Crossley's wire at Dean Clough to Midland-buildings, Bradford, whence the wire was carried to the office of Messrs. Salt in Well-street. From the latter place it was conveyed, through the Bradford Post Office, to Saltaire, where it was connected with Milner Field. At half-past ten, when the service at Square Chapel commenced, a dozen persons were present at the office at Saltaire, and evinced much interest in the experiment which was about to be tried. On the telephone receiver being applied in turn to the ears of those present in the office, the service in the chapel was heard with great distinctness. The voluntary played on the organ, and the singing of Hymns 933 and 16 in the Congregational Hymn Book were heard to advantage; but the *Te Deum* produced the finest effect upon the listeners. The prayer and the announcement of the text—Psalms i., 1-3— were quite audible, and the sermon was heard without difficulty. Had any one of the persons present applied the telephone receiver to his ear during the whole of the discourse, there is no doubt that, with the exception of a very few sentences, the whole of it would have been heard. The experiment was on the whole as successful as it was interesting. At Milner Field the result was equally satisfactory. It may be added that communication by means of the telephone has been maintained for more than a week between Milner Field and Moorside, Halifax, the residence of Mr. Louis Crossley, and Broomfield, Halifax, and conversations have been carried on nightly between various members of the family. In reference to the above-mentioned experiment, a correspondent forwards to us the following details:—"The total distance of line-wire in circuit was 14 miles. There were five listening stations and 12 telephones included in the circuit, and the transmitter was placed at a distance of three feet from the face of the speaker in the pulpit. The poles which carried the wire from Bradford to Saltaire carried also some 14 other wires, many of which were being busily worked, giving rise to a considerable amount of 'inductive noise.'"

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ON RECENT ADVANCES IN ELECTRIC LIGHTING.*

BY J. N. SHOOLBRED, B.A., MEM. INST. C.E.

Electric lighting in its application was hardly known in England twelve months ago, except for lighthouses; now there is hardly any large town in the United Kingdom where this illumination has not been publicly seen in some form or other, and for a period of more or less duration. In industrial works of divers kinds, in street lighting, in interiors, large and small, has this new form of illumination been tried. Its capabilities have been tested and ascertained, while at home the over-expectant requirements of the exacting public have been checked, and the proper sphere of the new illuminant more duly gauged and appreciated. Not that its ultimate development, though by steady stages, to that which has been too suddenly expected from it will not take place; but the progress to be sure must be steady. Some of the principal systems of electric machines and lamps by which the electric light was produced, were described before this Section at the last annual meeting of the British Association at Dublin by the author, in a paper entitled "The Present State of Electric Lighting." Most, if not all, of those systems then mentioned have held their own; but some fresh apparatus has been added to the list, and further improvements in others have taken place, in accordance with the further discoveries of science, and also with requirements, which have been found necessary. It is in improvements and adaptations to the requirements of actual practice that the hope of the future extension of electric lighting lies; and, it must be added, the progress realised during the past twelve months towards the solution of many problems has been very great.

The actual requirements of practice, and especially the competition entered into both in Paris, in London, and elsewhere, with the improved gas illumination showed the need for electric lights of more moderate illuminating power. Attention, therefore, has been directed during the past twelve months among electricians chiefly to the production of these smaller light centres; and to the solution of the divisibility of the electric current, so as to produce a number of lights, each of moderate dimensions, instead of one single one of considerable illuminating power. This, it was confidently stated twelve months ago, could not be effected, except at so considerable a loss of illuminating power as to make it not worth while the attempt. Now, however, thanks to the persevering attempts on the part of several makers of electric light machines, notably the Gramme, the Lontin, the De Meritens, &c., and to the attention paid to that class of burners termed candles, chiefly those of Jablochkoff, De Meritens, Rapieff, Wilde, Jamin, &c., the conditions are reversed. For it may clearly be shown that a much more effective and more generally diffused illumination, especially if the area to be illuminated is considerable, may be provided from a single dividing light machine with alternating currents, and using burners of the candle type (notwithstanding the *nominal* loss in the aggregate in the light which may result) than from a series of continuous current machines, each giving off a single light of considerable intensity, and using a lamp of the regulator type; the same amount of indicated horse-power being used in both cases.

This amelioration in the dividing light machines has been effected in great measure by a re-arrangement of the circuits composing them; rendering the product of each to be of more moderate dimensions, and so to speak, more handy.

The improvement in the apparatus connected with electric lighting has not, however, been confined only to electric machines and to lamps or other burners for those machines; it has extended itself, and perhaps here has been its most marked progress to the motors which actuate those electric machines.

It is in adapting these motors to the exacting requirements of the electric light, particularly as to extreme steadiness and regularity of motion, that this progress has been most marked, especially in steam engines. Another form of motor, the gas engine, has also received a special stimulus from its apparent suitability to the production of the electric light, where the amount of illumination is not very great.

Another step in advance has been the appearance of a thermo-electric pile of such construction and of such magnitude as to be suitable to the production of a regular supply of an electric current sufficient for an illumination of several hours' duration, and at a cost which is commercially available for the purpose. This has been effected by the Sudre thermo-electric pile, an apparatus which has sometimes, however, been called the "Clamond pile," owing to a previous invention of this latter gentleman. An important, if not a vital question, remains yet to be solved, as regards this pile, and that is the amount of maintenance and repairs required by it, or in other words the life of the elements which compose it. If it should prove lasting, and economical in working, this thermo-electric pile will prove of great service for small electric illuminations.

Lastly, the question of the relative sanitary effects of illumination by electricity and also by gas has received considerable attention during the past twelve months, as also has that of the chemical properties of the resultant products. A comparison of the respective illuminations as regards both of these heads has been to manifest the advantage resulting from illumination by electricity, some doubts and misgivings having been insinuated as to whether this advantage really existed.

ELECTRIC MACHINES (GRAMME). NEW FORM OF DIVIDING MACHINE.—These machines differ from those which have been hitherto made, in that instead of two distinct machines, an excitor and a "light" machine, the two parts, though still quite distinct from each other, are in the new machines upon one shaft, within the same casing, and, to all appearances, form but one machine.

In the older machines the types made were 4-light, 6-light, and 16-light, which last, owing to improvements, is in this country known as the 21-light. With the new machines but two types are made at present. A small one, somewhat similar in size and in amount of copper and iron as the old 4-light. But owing to better arrangements internally, and to other modifications, though it absorbs about the same horse-power as the older one, viz., 4½ net, yet the number of lights can be augmented to 10 of moderate intensity, *i.e.*, of about 200 candles, and which in actual practice might be, perhaps, of somewhat less illuminating power. If it is desired to augment this intensity, it can be done with a candle using thicker carbons, but of course a lesser number of lights is the result, six or four, as desired. But at present small-sized electric lights are the *desideratum*.

The improvement in this class of machine during the past year has been to augment the number of lights from four to ten, with the same expenditure of motive power; the total aggregate of light given off being much about the same in both cases, though, of course, the smaller the number of lights the greater their individual intensity. The author is enabled to speak from personal knowledge on this point, as owing to the kindness of M. Gramme and of M. Fontaine, he was allowed to assist quite recently at some experiments, both photometric and dynamometric, which took place at their workshops in Paris, and where facilities were courteously afforded him to verify the measurements taken.

The second type of machine which is being made is one of about double the dimensions of the above, and supplying twenty-four lights, equivalent in intensity to the ten of the little machine, the probable absorption of horse-power being somewhat under ten.

THE LONTIN MACHINE.—The writer was also present at some experiments carried out at the workshops of Mr. G. P. Harding.

The same type of machine which twelve months ago was made to feed six lights, of nearly 600 candles each (such as were seen at the St. Lazare station in Paris, or at the Gaiety Theatre in London), now by a somewhat different arrangement of the circuits generated is made to produce twenty-four lights of a much more reduced size, probably of about 200 candles each, and this with certainly less horse-power absorbed. It must also be noticed that, owing to the facilities afforded by the key board on which are collected the terminals of the currents in these machines, different illuminating powers may be given to the resultant lights according as twenty-four, so to speak, elements, are more or less grouped together.

THE "DE MERITENS" MACHINE.—The construction of the permanent compound steel magnets of this machine, which were originally composed of thin plates of horseshoe form, are now constructed in a much simpler manner. Each limb of the magnet is perfectly distinct from the other, and is composed of straight thin plates of steel, rivetted together at the lower or open end of the magnet, while at the upper or round end of the magnet a single wrought iron bolt with a distance piece to keep the two limbs apart holds the entire of the plates of both limbs firmly together.

A very marked feature of this magneto machine is the very simple form and construction of the small induction coils which are ranged lengthwise round the periphery of the bronze wheel. These coils, the core of each of which is composed of fifty thin plates, are insulated nagnetically from each other, though connected electrically. They are treated like the elements of a pile, and may be coupled up in tension, or in quantity at will, thus obtaining for these machines a property which sometimes may be very valuable.

The new form of machines produce a greater number of lights, and are themselves more economical in cost than previously.

THERMO-ELECTRIC PILE (SUDRE).—In a circular hot air furnace,

* A paper read before the British Association, Section G, Sheffield, August, 1879.

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placed vertically; the heated air is forced to descend, and then ascend through cast-iron flue chambers, heating them, and acting upon an electric chain placed vertically, composed of small cubes of an alloy of zinc and antimony, the several cubes being connected together by strips of zinc fastened into each cube. Radiating from the zinc cubes from the opposite face to that acted upon by the hot air are placed vertically a series of thin copper sheets, radiating from each other like the leaves of a partly-opened book. The difference of temperature between the two poles of this couple is about three times. The zinc being heated to 240°C. (464° Fahr.), while at the outside edge of the copper leaves (which act as a distributor of the heat, and consequently as a cooler) it is reduced to 80° C. (176° Fahr.) Asbestos paper is used as an insulator at the back of the zinc cubes, where required.

The pile (shown in diagrams) is a double one; one above the other. Each pile contains 3,000 elements (*i.e.*, 30 chains of 100 cubes each).

The total electromotive force is 218 volts = 120 Bunsen cells. The total resistance is 31 ohms = 3,100 metres (3,380 yards) of telegraph wire.

The above pile is heated ordinarily with coke; about 30lbs. being used to get it up to the requisite heat, in about 1½ hours, after which an hourly consumption of 20lbs. is required to maintain the requisite temperature.

With the current from each pile supplied separately to a Serrin lamp, each gave a (noiseless) light of about 400 candles. The two piles could be coupled together (in quantity) to supply a single Serrin lamp of considerably increased power.

Or, as in another smaller pile (intended for the Albert Hall), and differently arranged, four smaller lights were supplied, each of about 200 candles' intensity.

SIEMENS' PENDULUM LAMP.—The chief distinguishing feature of this lamp is its comparative simplicity, as against the older forms by the same maker, and, indeed, against the Serrin and most others of a similar regulator type. The number of wheels constituting the clockwork movement, as used in all of these, is greatly diminished in this lamp, and replaced by a pendulum escapement.

Two movements are necessary, as is the case in most other lamps.

1st. An upward movement to cause the requisite approach of the carbons for the production of the electric light; and also to vary the distance between the points of the electrodes, according to the strength of the current.

2nd. A feeding movement, to ensure the regular approach of the carbons according to the rate of consumption by burning.

To control and produce the first of these movements a solenoid or hollow spiral, with a plunger working into it, is made use of, instead of the electro-magnet and its armature, which is ordinarily employed.

Attached to the plunger is the end of a lever, the other end of which is hinged to the fixed frame of the case. Intermediately there is attached to this lever an upright oscillating frame carrying a bearing guide on its top for the lower carbon holder which in its lower part has on one edge a vertical rack, working into a toothed wheel fixed on the upper part of the oscillating frame. The axis of this toothed wheel carries also the pivot of a pendulum, the rod of which last is prolonged upwards, and is locked while wanted in a notch in the underside of a small horizontal catch. One extremity of this catch is hinged upon the oscillating frame, while the other extremity, beyond the notch, is free to move upwards, and by doing so to release the pendulum, and leave it free to work.

Any upward movement of the plunger into the solenoid imparts at the same time a corresponding movement to the oscillating frame, and carries up with it the lower carbon holder.

When left to themselves by the cessation of the movement of the plunger (*i.e.* of the electric current), both oscillating frame and carbon-holder descend by their own gravity to a certain point; which is the limit of the play of the oscillating frame, where its progress is arrested. If, however, the carbon points continue still too far apart by reason of consumption to make a proper light to be maintained, the carbon-holder is set free to continue its downward course alone, until again arrested by the upward movement of the plunger, and due to the electric current itself, and carried in that direction. This release of the carbon rack from the oscillating frame, and the proper control of the continued downward movement, so as to ensure a regular and and not an accelerated arc, is effected in the following manner:—

When the oscillating frame has reached its limit of descent, the little horizontal catch is thrown upwards by striking its free end against a projecting fixed pin in the lamp frame. This action releases the upper part of the pendulum; the latter begins to act, and at each beat causes the rotation of the pinnion wheel on the same shaft. The teeth of this wheel working in the rack of the carbon holder allows the latter to descend only at the regular rate of motion of the pendulum-beats.

In order to render still more regular the action of the plunger, it acts in descending upon a small air pump beneath it; and to aid the upward movement of the plunger, there is a small counter-weight.

To speak briefly, the downward movement of the upper carbon holder (the bottom one being fixed), required by the gradual consumption of the carbons, is effected by gravity controlled by the action of the pendulum, while any movement in a contrary direction is controlled by the electric current itself by means of the solenoid, and the plunger working in it.

(The author next described Heinrich's circular carbon lamp, which we have since illustrated.)

ELECTRIC "CANDLES."—Much attention has of late been directed to the more economical form of burner termed "candle," from the two carbon-rods being placed side by side, and both consuming at an equal rate. To effect this object electric currents alternating in direction are almost invariably (though not necessarily) used.

The only type of this class in use twelve months ago was the "Jablochkoff" candle. With it originated the name "candle," and it is still the most extensively used of this class of burner. In its original form it possessed the disadvantages of having the carbons rigidly fixed, and without the power of adapting the distance between them to the variations of the electric current or of relighting itself when extinguished. The property of relighting has since been acquired by a variation in the composition of the insulating substance—itself a source of delicacy in the manufacture of the candles and a cause of the absorption of much electricity whilst alight, zinc filings and shavings of box wood being added to the plaster of Paris and barytes formerly used, the oxide of zinc formed by the action of cooling subsequent on extinction affording the necessary conducting medium for the current to pass from one carbon to the other, and so to cause relighting. This improvement does not appear, however, to be much used, nor to have caused the older form to be discontinued.

The "de Meritens" candle dispenses altogether with the insulating substance, one or even two insulated carbon rods being substituted in its place. The electric current in its passage from one outside main carbon to the other causes induced currents to act upon the extremities of these central carbons.

A form of candle generally known as the "Wilde," but first devised by Rapieff, is superior in simplicity, efficiency, and economy to the preceding ones. In it the carbon-rods are placed in two separate holders, one fixed, the other having a pivotting action, and responding to the movements of the armature of a magnet, through which the electric current passes. No insulating substance is needed, the carbon rods being used in the form in which they come from the maker, itself a considerable economy. Relighting is produced by the falling together of the carbons, consequent upon the current ceasing to pass through the magnet; while the degree of separation of the carbons is controlled by the current itself.

Another form of candle, the "Jamin," has been the subject of some controversy of late, as to its real merits. The two carbons are fixed immovably at the requsite distance apart, and without any insulating substance between them. The wire from one of the carbon rods, instead of passing away directly, is wound round the carbons in the vertical plane of the two rods, and at a distance on each side of about ¾ of an inch. The wire, with an insulating covering throughout its entire length, is wound round about five times; and the turns are gathered together and made up into one coil. The inductive effect of the current circulating round the candle is supposed to conduce to the steadiness of the flame produced; but "Count du Moncel" has already shown that the effect of this "insufflation" is produced at the expense of considerable loss of electrical power.

MOTORS.—In steam engines used for electric light a great improvement has taken place in delicacy of governing arrangements, and in rendering the adjustment automatic, so as to counteract any ill effects of irregularity in motion caused by the ever varying strains thrown upon the motor by the electric machine, this excessive regularity in the speed of the motor being rendered necessary by the great difference in rate of motion between itself and that of the electric machines—a difference which tends to magnify in the high speed electric machines any irregularities in the slower motor power. From the 70 or 80 revolutions per minute of the agricultural engine the motor for the electric light has advanced to the 250 per minute of the locomotive type of engine, and even more, as in the direct-acting 3-cylinder engine of Brotherhood.

The arrangements which have been adapted to most of the steam engines intended to be used with the electric light, and more especially to the agricultural engines of the portable or semi-portable type, consist generally of a very sensitive governor,

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acting automatically either upon the throttle valve, or upon a second slide valve, perhaps more generally the former.

The governors mostly employed are of the Porter, the Brown, the Hartnell, the Buss, &c., kinds, or modifications of them. The ingenuity and devices shown in many of these numerous arrangements, all to effect the same object, present a series of most interesting solutions of this most important problem in the production of the electric light, that of extreme regularity in the motive power.

The examples about to be named are, it is understood, among some of the most successful in effecting the desired object; but it must not be supposed that others, which, through want of space, have been omitted, may not be equally so.

Ransomes, Sims, and Head.—In the application of the Jablochkoff system (as it is somewhat erroneously called) on the Thames Embankment in London, a 20 horse-power nominal semi-portable agricultural engine is used. As this example of electric lighting has been carried on without interruption for a longer period than perhaps any other in England—ever since the middle of November last, some nine months—and, moreover, as the performance of the engine, more especially as to its regularity of speed, has been adverted to by the officers of the Metropolitan Board of Works, in their report to that body, in high terms of praise, it may not seem out of place to begin with this example. "The apparatus consists of two small excentrics (lower rod A and B upper rod) fitted on the crank shaft, and fitted in the ordinary manner. The other ends of the excentric rods are connected together by a solid link, F, which slides in a block carried by the rod of the cut-off valve. The weigh-shaft, H, the arms, I, and the supporting rod, J, form the connection between the link and the governor, K, which is on the Porter principle.

"Its action is as follows:—The excentric A, the rod of which is attached to the *lower end* of the link, is fixed at such an angle in relation to the crank as to effect an *early* cut-off, whilst the excentric, B, attached to the *top* of the link, is set so as to effect a *late* cut-off. When the load on the engine is diminished or increased (which the ever altering resistance of the electric machine and of the external circuit and lights is always doing), the governor revolves above or below its normal speed, and, by the rising or falling of the arms or balls, ships the link and brings the expansion valve (which is in addition to the ordinary one) more or less under the influence of the early or of the late cut-off excentric, thus regulating the supply of steam until the normal supply is required for the proper number of revolutions (which is effected by the ordinary slide valve)." In the example on the Thames Embankment the average number of revolutions per minute was 142·36, that number never being exceeded, it is understood, by about two revolutions in excess of or below that figure.

Duvergier, of Lyons.—This engine, of which the author has seen a 10 horse-power, nominal, example in Paris, at the workshops of the Société Lyonnaise l'Electricite, where the De Meritens magneto-electric machines are made, is there used not merely to drive all the machinery of the shop, but also to produce the electric light for its illumination, and for any experiments which may be required. The extreme steadiness of the resultant electric light, notwithstanding these manifold duties of the motor, caused the author to remark its particular construction, some of the peculiarities of which are worth remarking. This type of engine seems, naturally, to follow the preceding, as in it the form of automatic control is also by means of a second slide-valve, as in the previous case. A distinctive peculiarity of this engine is the use made of this second slide-valve at the commencement of its course to start the engine, a small hand-wheel upon the spindle controlling the early admission of steam to the cylinder. The engine in question is a condensing one; it is provided with a very compact, and apparently very effective condenser, presenting a somewhat novel construction.

Marshall and Co., Gainsborough.—This peculiar form of governor acts through a link and die on to an expansion cut off valve, working at the back of the main slide valve, thus regulating automatically the supply of steam in proportion to the speed.

Robey and Co., Lincoln.—This governor, a modification of the Porter, works horizontally, and by means of two wedge-shaped lugs below it, acts upon the excentric of the slide-valve by forcing, as the balls either rise or fall, one or other of these wedges into the excentric, thus lengthening or shortening its throw, and consequently the greater or lesser opening of the slide valve, according as more or less steam is required to preserve the normal rate of speed.

Turner and Co., Ipswich.—The appearance and construction of this governor are peculiar; it is based upon Hartnull's governor, and it is enclosed in a circular box. Two curved weights connected together replace the ordinary governor-balls. When they fly out towards the outside of the box, or close in upon the crank-shaft in the centre, there is carried with them a curved quadrant, which by its curved face acts upon an excentric to the slide-valve rod. Thus a greater or lesser stroke is given to the excentric, and consequently more or less travel to the slide valve, in proportion as the curved weights close in upon the centre or fly out towards the outside.

The expansion of the weights is controlled by springs, which may be adjusted by screws.

Shanks, Arbroath.—Equilibrium governor. The arms or pendulums of this governor are balanced, so reducing the friction. The opening out or falling down of the arms acts by means of a centre boss upon a spring coiled round the shaft, which acts directly upon the throttle valve, without the intervention of brackets or levers. The rate of the engine can be readily altered by means of the screw outside of the circular case which encloses the governor; by this means the spring inside can be tightened up or loosened out according to the speed required.

Clayton and Shuttleworth, Lincoln (not shown in the diagrams), cause the governor to act upon a second slide valve, the expansion of the valve being caused by the action of a right and of a left hand screw simultaneously, somewhat as in a railway carriage coupling. It is said, however, that after a time the threads of the screws are liable to rust from the action of the steam, and thus impair the efficient action of this ingenious contrivance.

Gas Engines.—Another effect of the desire for the production of the electric light has been the stimulus which has been given thereby to this class of motor, which has been found to be extremely handy and cleanly where a small amount of power is required, and where the proportion of expense of skilled attendants would be great as to the amount of motor power required.

The Otto-Langen "Silent" Gas Engine, as made by Messrs. Crossley, of Manchester, is by far the most generally used of these engines. It is so well known, and so extensively used, that it is needless to attempt to describe it.

Suffice it to say that an explosive gas, generally common coal gas, as used for domestic illumination, is admitted into a cylinder, together with atmospheric air, in a proportion deemed most sustable to the quality of the gas used. The mixture is therein exploded by access to a small gas jet, which is kept constantly burning in an adjoining recess. The number of explosions is variable, according to the nature of the work, *i.e.*, the engine runs on with the force of the explosion as long as it can do the work, and when the power begins to fail a fresh admission of explosive mixture takes place, and another explosion is the result. The maximum number of explosions, however, with this engine is half that of the number of revolutions of the fly-wheel, *i.e.*, an explosion for two complete revolutions.

The consumption of gas, with an admixture of atmospheric air of the ordinary amount, may be taken on an average at about 22 cube feet of gas per indicated horse-power per hour. Sometimes it may fall below this, sometimes somewhat above; but this figure has been the result of very careful investigations by many reliable, independent inquirers. At the average price of gas in England, 3s. 9d. per thousand, the price, as given by the makers, of 1d. per indicated horse-power per hour may be taken as correct.

The Eclipse Gas Engine.—"The gas is *not used* explosively, but for the rapid expansion of atmospheric air previously mixed with it, and compressed in an air pump forming part of the engine. A further distinguishing feature is the addition of a steam-generator, which surrounds and surmounts the working cylinder. The heat given off by the gases in the latter generate steam of about 60lb. pressure, which is used for increasing the power of the engine. The steam assists also very materially to lubricate the piston, and the cylinder being surrounded by a water jacket can never get hotter than the steam."

Clerk's Gas Engine.—(Thomson, Sterne, and Co., Glasgow.)—This engine consists of two cylinders, a compressing cylinder where a mixture of gas and air is taken in and compressed to about 60lbs. per square inch; this is then passed when required to the motor cylinder, where the mixture is exploded, expanding about four times in volume.

The means by which the explosions, which take place with each stroke of the piston (*i.e.*, each fly-wheel revolution), are caused is peculiar. A small platinum screen or cage, enclosed in a box of non-conducting material, is first brought to a white heat by means of a jet in a small reservoir; once hot it suffices to pass the compressed mixture against it to produce the explosion, which acts upon the piston. The effect of this explosion is sufficient to maintain the platinum at the required temperature to cause the next explosion.

It is claimed that this engine works steadily and regularly, and consumes less gas per indicated horse-power than either of the preceding ones.

Not sufficient time has yet elapsed since the first appearance of this engine to thoroughly test its capabilities.

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THE ELECTRICIAN.

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THE USE OF PROPER NAMES IN CODE TELEGRAMS.

We publish this week a number of communications, which have been addressed to *The Times*, complaining of the restriction on the use of "proper names" in code messages, viz.: "That they must be used only in their natural sense," which was adopted by the recent International Telegraph Convention. It is most desirable that the purport and expediency of the restriction in question should be discussed and fully considered, and that the nature of the alternative course which would perhaps of necessity be adopted if this restriction were abandoned should be clearly understood. The question at issue is one in which the interests of the Telegraph Companies, as well as those of certain amongst their customers, have to be considered; and, these interests not being in all cases identical, a fair balance has to be struck between them. At the same time, the interests of all those who use the Companies' lines without employing any code system have equally to be kept in view. Bearing these points in mind, we confess that we see immense difficulties in the way of rescinding the restriction complained of, and that the expediency in any case of so doing appears to us very doubtful.

The letters in *The Times* adverse to the new regulation adopted by the Conference proceed evidently from merchants who largely avail themselves of the telegraph, and who have devised and adopted systems of code signalling. Their object—a most legitimate one under limits which exclude advantages never anticipated and detrimental to other interests—is, of course, to cheapen telegraphic transmssion, by making one word suffice where three or four have hitherto been requisite. By the use of an extended code, this economy can be carried out very effectively; and the greater the number of words in a code the greater is the saving thus practicable. Indeed, it is beyond doubt that, with a code of half a million words, a merchant might express by a single word almost every message that could be requisite in even a large and varied business. Now the merchants allege as a grievance that the Companies are opposed to the use of code language. *Primâ facie*, it would appear natural that this should be so; but we have no evidence whatever that the Companies have placed themselves in antagonism to the use of code messages, as such, although they may latterly have realised a serious objection to the employment of words which lend themselves readily to permutations by which many varied meanings may be expressed. The rules hitherto established by the International Conferences admit of code telegrams in all the European languages. Experience, however, showed that certain restrictions in this direction were unavoidably necessary. Thus the number of letters in each word was at one time limited only to fifteen; but this was taken advantage of to such an extent that complicated codes were constructed in which every syllable conveyed a different expression. In foreign languages, and even in English, the syllables were arranged obviously under a system by which advantage was taken of the *maximum* limit of fifteen letters. And it is apprehended that what was then done with *syllables* may now, especially by the unrestricted use of "proper names," be done with *letters*. At the St. Petersburg Conference, the number of letters in a word was reduced to ten; but codes were then constructed in which the *maximum* number of ten letters was adopted as a basis, the changes being rung upon syllables. Thus a telegraphic jargon was constructed which, within certain limits, could scarcely be checked or objected to. But very many of the words challenged as undiscoverable in any known works were alleged to be "proper names;" and the consideration of these words brought to light the fact that any combination of consonents with an occasional vowel might be alleged to be a proper name. It was under these circumstances that Conference was asked to define what should be called "language" for code purposes. But, with respect to what is regarded by the Companies as the legitimate use of code messages, it may fairly be claimed for them that it was through their influence, exerted without any outside pressure, that the consent of the International Telegraph Conferences was obtained for the use of code language at the tariff for ordinary language. We may go further and state, without fear of contradiction, that the Companies first introduced the word-by-word tariff now about to be universally adopted, and according to which

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those who employ the telegraph pay only for the number of words, however few, they require to send.

An important point in the case brought forward in *The Times* by merchants using code language is that, in making any restrictions whatever to the kind of words in use, the Companies do not understand their own interests, and do not realise that merchants would telegraph perhaps ten times as frequently as they do now, if telegraphing were cheaper and without restrictions. But in opposition to this view, considering that at the present time, notwithstanding the restrictions imposed, any merchant can make a code, out of 100,000 words, embodying half a million sentences, each expressed by no more than three words, it may fairly be held that the Companies have a right to stipulate that these words shall be reasonably simple, and such as are least liable to error in telegraphic transmission. And, in the second place, the Companies hold, and probably with reason, that it would be a mistake to suppose that, if all restrictions were removed, merchants would employ the telegraph ten times, or even five times more frequently than they do at present. It has in fact been found by experience that a considerable reduction of tariff increases the number of messages from previous customers only to the extent of twenty-five per cent. And there is no doubt but that, with an extended code, the messages would become fifty per cent. shorter. It should be borne in mind that, ten years ago, the average number of words in a message was *thirty;* it is now only *thirteen,* and if we exclude Press Packing Agency and Government messages from the calculation, the average is not more than *ten.* If a letter tariff were adopted, it is probable that the average number of words per message would be five or six only. It would thus be many years before the loss incurred on the first adoption of this system could be recouped.

It is argued also that the Companies fail to recognise what is inevitable, or to perceive that the removal of all restrictions is in the interest of telegraphic property, and is calculated to increase revenue, whilst benefiting the mercantile community. To this the Companies reply, in effect, that restrictions of any kind would never have been heard of if plain language, such as is ordinarily used, had been adhered to. They are prepared to allow any latitude to ingenuity and economical contrivance, so long as such language is used; but they think they have a right to consider their position, and look to the interests of their shareholders, when it is sought to force upon them combinations of every imaginable kind, giving them the *maximum* of trouble with the express object of giving them the *minimum* of payment.

The case as between the Merchants and the Administrations may perhaps be summed up in the brief statement that the former would wish if possible to compress all usual messages into one code word; whilst the latter, through the International Conference, claim to have something to say as to the kind of words to be used. For our own part, we fail to perceive that the removal of the restriction complained of would be attended with generally beneficial results; nor do we think that more than a small per centage of those who use the telegraph lines consider themselves to be aggrieved by the restriction in question.

COMPLETION OF THE FIRST SECTION OF THE NEW FRENCH TRANSATLANTIC CABLE.—The directors of the Company owning this cable have received from America a despatch announcing the successful laying of the section from Newfoundland to the Scilly Islands. The extremity of the cable is buoyed off the bank of Newfoundland, and the Faraday has returned to England for the shore end, and the line to connect Newfoundland with New York.

CORRESPONDENCE.

SPLIT BATTERY DUPLEX.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: Referring to Dr. Muirhead's letter in your issue of the 3rd May, 1879, in which that gentleman, in the most confident manner, contradicts a statement made by the late Mr. R. S. Brough on the subject of Split Battery Duplex in India, will you allow me to show that Mr. Brough's statement is as correct as Dr. Muirhead's is the reverse.

Dr. Muirhead did see a split battery system of duplex at work in our office at Madras, but the system was that of Mr. O. Heaviside, modified by Mr. Briggs in so far that a short circuiting key was used to produce the signals, and further improved by Mr. Brough himself, a point that with his innate modesty he omitted to mention.

The service rendered by Mr. Briggs in the matter has been fully acknowledged by the Director General of Telegraphs in India, a service of which neither the late Mr. Brough nor any one else has ever attempted or desired to deprive him.

I will answer for it, and Mr. Winter will, I feel sure, admit that Mr. Brough did not betray any confidence imposed on him with regard to the double-tongued relay.

In fact, the clearly worded and accurate statements of Mr. Brough defy contradiction, and it is to be regretted that Dr. Muirhead, with his imperfect information on the subject, should have attempted it.—Yours truly,

W. P. JOHNSTON, Indian Government Telegraphs.

Electrician's Office, Alipore, Calcutta, Aug. 22, 1879.

NOTE ON THE CONSTANCY OF CAPACITY OF CERTAIN ACCUMULATORS.

BY DR. ALEXANDER MUIRHEAD, F.C.S.

The object I have in view in making this communication is to draw the attention of Section A of the British Association to the desirability of issuing a temporary standard of electrical capacity, the want of which has considerably increased since the last Report of the Committee on Electrical Standards, September 4, 1867.

At that time it was thought worth while to issue a provisional unit of capacity to meet the requirements of the electric telegraph service, in the shape of a mica-paraffin condenser of capacity to be determined by the ballistic method; but according to the report no decision had then been arrived at whether the new unit should be issued by the Committee or on Professor Jenkin's own responsibility. In an appendix to that report, Professor Jenkin has published the results of several determinations of the capacity of a certain condenser of Mr. Latimer Clark's construction, adjusted to equal 10^{-14} electro-magnetic absolute units; in the values he obtained there was an approximation of only ·42 per cent. between the mean and any single result, so that copies of such a preliminary standard would probably not have been correct within much less than 1 per cent.

This apparent variation of capacity was due chiefly to the absorption of charge by the dielectric used to separate the conducting plates; and, I believe this condenser, and others made like it at the time, have failed altogether in insulation since.

In 1869 I carried out a series of experiments for Messrs. Clark and Muirhead, to determine the best and most durable dielectric to use in the construction of condensers for the electrical testing and working of submarine telegraph cables, and I soon found that a given dielectric absorbed less the freer it was from foreign matter. The materials that seemed best suited for the purpose were paper, mica, paraffin, and shellac. Several condensers were made in the manner described by Professor Jenkin in Appendix IV. to the above-mentioned report, in which these materials were used, purified in different ways, great care being taken in every case to prevent the deposition of moisture on the plates during the construction of the condensers. The plates that showed the least amount of absorption, with ordinary differences of potential, were those made of mica coated with shellac that had been purified with absolute alcohol. The condenser which I now exhibit was constructed of such plates, and its capacity adjusted to equal one-third of a microfarad on comparison with four condensers lent to me by Mr. Latimer Clark and Mr. Forde, one of which was the condenser referred to above in Professor Jenkin's report, and the other three were made from it by Messrs. Laws and Lambert. According to my own determinations at the time, by the ballistic method, using a needle whose period of vibration was eight seconds, its value was ·331 microfarad, and I decided

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to take as correct the mean ·332 of this, and the value ·333 got by comparison with the four condensers referable to Professor Jenkin's determinations. Ever since then, copies have been made of this condenser and supplied by Elliott Brothers, the late firm Warden and Co., and Clark, Muirhead and Co. to manufacturers of scientific apparatus and others as standards; the number so issued is over 600. From the close agreement of the determinations just made by Mr. Hockin (a member of the late committee on Electrical Standards), of the capacity of this condenser with mine made nine years ago (*vide* his note appended to this), it will be seen that probably no change greater than one-third per cent. has taken place in it, and, therefore, one might confidently recommend the British Association either to adopt this form of condenser as their temporary standard, or to appoint another committee to re-investigate the subject. I might add that I found very little absorption in condensers of brass plates embedded in paraffin wax allowed to solidify under pressure, and also in some made with silvered glass plates embedded in the same manner. In the absolute determination of the capacity of these condensers by discharge through a galvanometer, no greater differences than one-third per cent. need be made in the results, even with needles varying in period of vibration by as much as from 2½ seconds to 25 seconds. This is the result of experience; and in defining the capacity it will be sufficient for all practical purposes to specify complete saturation of the condenser and the method of measurement adopted.

I have asked Professor Ayrton to draw the attention of the section to the fact that there is no one authorised to certify to the correctness of copies of the various electrical standards originated by the British Association. I would suggest that some public body, such as the Kew Observatory, be asked to undertake the labour of comparing resistance coils, condensers, absolute electromotors, against the standards to be lodged by the British Association for the purpose.

Value of the condenser from comparison with four condensers lent by Messrs. Clark and Forde 1869	·333 mf.
Value of condenser determined by Dr. Muirhead, January 1879, from throw of galvanometer needle..	·331 mf.

Values obtained by fall of potential through small resistances—10,000—vary according to time; for short time, ·001 sec., the condenser comes out ·3305; for much longer time, ·1 sec., it comes out ·335 mf.

REPORT OF THE COMMITTEE ON ATMOSPHERIC ELECTRICITY IN MADEIRA.*

BY DR. M. GRAHAM.

Remarkable fluctuations of the electric potential were noticed at the time when the maximum potential is reached, which takes place at 11:30 a.m.; this fluctuation the writer ascribes to masses of cloud on moist air. The daily formation of a thin stratum of cloud during fine calm weather, which varies slightly in altitude in accordance with temperature and barometric pressure, was described. The electricity below this cloud is always positive, and moderately strong. In the cloud itself it is more feeble, but of the same sign. Above the cloud, at the station where the observation was taken, it was very feeble and irregular, but always positive. In warmer weather the vapour does not condense into cloud, but appears as a blue transparent haze from above, and presents the same electrical indications.

The highest potential was observed upon a rock ninety feet high, a few metres from the shore in the Bay of Funchal.

The thinness of the currents of air constituting sea breezes was demonstrated by flying a kite vertically beyond into the true wind blowing in a contrary direction. Abortive attempts were made to bring down the upper electricity through the lower currents. The electricity of the general north-east wind which is identical with the trade wind was found on the heights at the east end to be uniformly moderate and positive.

At the approach of rain-clouds at the termination of a period of fine weather the atmosphere invariably gives increased readings and no negative observations were recorded.

The L'este, a kind of sirocco to which Madeira is occasionally subject, electrically gives no indication of any change whatever except by faint fluctuations about the earth reading.

During the prevalence of L'este wind, the writer noticed a very highly electrical condition of certain clouds which lie quietly among the mountains, though tossed and tumbled on their upper surfaces; he hopes to be able to connect their forms and immobility with their electrical change.

* British Association.

CHICAGO GENIUS.

IT HAS PRODUCED A GREAT IMPROVEMENT ON THE TELEPHONE.

Anyone familiar with the growth of valuable inventions knows how their usefulness increases with their age, as improvements are added. When Stephenson, building his first railway, was asked what speed he thought he could attain, he replied that he had no doubt he should ultimately be able to run a train four miles an hour without danger. How complex and perfect is the locomotive and steamboat of to-day compared with the same inventions thirty-five or forty years ago, the reader knows. Judging the telephone by other "epoch-forming" inventions, one can hardly go wide of the mark in predicting what it will finally be capable of; and there are many competent judges who say that before many years it will be possible for persons to converse between New York and Chicago with it. Of course, this extraordinary achievement will be reached by slow and laborious steps, by one man adding an improvement here, and another man a different improvement there, until the result named is within reach.

One such addition to the common fund has just been made by Mr. F. W. Jones, the chief operator in the Western Union Telegraph Office in this city. All users of the telephone are familiar with the fact that where many offices are on the same line the voice does not go through to the final telephone distinctly. The finer tones of the voice become lost, and the part that comes through is weak and low. Suppose a gentleman have a line between his office and his house, and there are no other telephones on that line but those two; when he speaks through it his voice passes distinctly, and when he listens he can recognise by the tone who is at the other end; but where there are many intermediate telephones, and the voice has to pass through the coils of wire that are in them all, the words can barely be heard, and recognition of the voice is utterly out of the question. Mr. Jones's invention remedies all this, makes it possible to have as many telephones or telegraph instruments on a line as are wanted, and still let the voice come through as distinct as if there were but the two terminal instruments.

To understand how this is, a little explanation is necessary. Imagine two wires parallel, and not very far apart. Send a current through one wire, and there will be a current produced entirely by sympathy and sent through the other wire in the opposite direction. This is a very common phenomenon, and the second current is called an induced current. When the wire is in a coil, as is the case in an artificial magnet, the induced currents are very many, and are made by the main current acting on the adjacent turns in the wire. With a great number of these induced currents conflicting with the main current on the single wire, the effect is to completely obliterate all the finer tones of the voice and to transmit to the terminus of the wire only the general blur or body of the articulation. Mr. Jones's device is to take a long piece of fine wire, double it in the middle, and wind it around a bobbin. When a current is sent through this it passes around the coil one way, and back again in the opposite, of course, because the wire is doubled and thus wound back on itself. The induced currents, moving in an opposite direction, are neutralised by the main current, or by a portion of it, and the remainder of the main current passes on intact. This "shunt," or bobbin, is attached to the main telephone wire so that one end is in front of the telephone and the other back of it, and its resistance is made just equal to the resistance of the telephone. The current divides at the front connection, half going through the shunt and half through the telephone, and as half the ordinary current will keep the intervening telephones quiet, the shunt is made self-acting. It is a very ingenious thing, and costs but a trifle. The effect on the working of a telephone is wonderful. A reporter of *The Times* tried a telephone, yesterday, without the shunt, and the voice from the other end could scarcely be heard; but when the shunt was applied the change was instantaneous and magical. Every tone, and every element of the tone, came through with the utmost distinctness, and the voice sounded fully four or five times as loud. Mr. Jones's invention seems to be second in importance only to Edison's carbon button, so far as relates to telephones, and it will have the effect to at once render that valuable instrument very much more practicable. It is to be patented at once, and will soon be ready for general use.

Mr. Jones's inventive faculty has done good service before in electrical science. He has patented a neutral relay that has made the hitherto unsatisfactory quadruplex telegraph—a combination of instruments for the transmission of four messages over a single wire simultaneously—almost as good as four single wires. The quadruplex is worked by a reversal of currents, one relay or instrument being worked by the direction of the current,

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and the other by the strength. The improved relay has its cores and convolutions reduced to the lowest point consistent with the magnetic force required, allowing it to decline the effect of one current, and to accept that of another almost instantly. Edison invented the quadruplex, but failed to make it work satisfactorily. Mr. Jones has made it practicable, and the efficiency of his instrument is seen from the fact that the Western Union Telegraph Company have thrown out all other experimental neutral relays, and has adopted his throughout the entire United States.—*Chicago Tribune.*

LITERATURE.

The Students' Text-Book of Electricity. By H. M. Noad, F.R.S. New Edition. Carefully Revised, with an Introduction and Additional Chapters, by W. H. Preece, M.I.C.E. [London: Crosby Lockwood and Co.]

Second Notice.

The chapter dealing with magnetism has similar faults to those previously mentioned, but we think that, on the whole, it is better than the preceding. The student is told "how," if not "why," and many experimental phenomena which have been practically utilised are described, and are not to be found in similar works. Electro-Physiology is next discussed, and then we come to that portion of the work devoted to Voltaic Electricity. To the chemical portion of this we must emphatically object. It is enough to be in the midst of squabbles as to the correct mode of symbolising sulphuric acid—whether we are to write H_2SO_4 or SO_2Ho_2; but to complicate the chemistry of electricity by using the symbols HSO_4 for sulphuric acid, is asking the student to allow too great a license. It is not too much to say that the student, who ought to have some smattering knowledge of chemistry, would in vain hunt in the ordinary text-books for the name of the substance represented by HSO_4. The nomenclature, as given on page 173, for example, is as if the compilers of the standard reading books in our national schools were to print the books in Old English type with the ancient form of spelling. Is the author everybody? and is the student nobody? Is the one to be allowed to do as he pleases in order to double and treble the work of the beginner? Surely life is not long enough that extra work should be thus thrown in gratuitously.

The more we consider this fault, the more we regret that the editor did not take the bull by the horns, and, respect for the author notwithstanding, pitch such paragraphs into the waste-paper basket and into oblivion. What can the schoolboy make of such a table as the following:—

Before the plates are connected.

$$Zn \quad \overbrace{SO_4H} \quad \overbrace{SO_4H} \quad \overbrace{SO_4H} \quad P$$

After the plates are connected.

$$\underbrace{ZnSO_4} \quad \underbrace{HSO_4} \quad \underbrace{HSO_4} \quad H-P$$

He will reason that zinc is a diad, and therefore one atom of Zn replaces two atoms of H, but this table goes contrary to his teacher. In other words, whenever a student uses this work he must undertake a systematic translation of its chemistry into the chemistry of his everyday life.

The paragraphs relating to Ohm's Law, Wheatstone's Bridge, Electrical Units, &c., are epitomised from the Author's Explanation, the British Association reports, or some equally reliable source. The chapter on the Chemical Powers of the Voltaic Arc and Electro-Metallurgy is weak, but this is counteracted by the interesting information given in the following chapters on Thermal, Luminous, and Magnetical Effects. That portion of the work which describes the magneto-electric apparatus, inductive apparatus, stratification, &c., is better than any that precedes it, and we cannot point to any other English text-book which treats this question so freely.

MILITARY TELEGRAPHY IN AUSTRIA.

Since 1873, the regiment of Pioneers has been charged with the duty of training and providing men who will form special railway and telegraph detachments. So long as the army is on the peace footing, the men who are destined to form the telegraph detachments remain attached to their respective battalions of the Pioneer regiment. They are trained and exercised in all the ordinary duties of the pioneer soldier, and once a year they have a course of special training and exercise in field telegraphy. In case of war all these specially-trained men can be withdrawn from the Pioneer service and formed into a special corps. Each Pioneer battalion is required to be able to furnish eleven telegraph detachments. This would give a total of fifty-five detachments, who with their *matériel* and appliances would at once constitute a telegraph network 110 (440 English) miles long, and embracing 220 stations. The yearly exercise of the detachments stationed in the neighbourhood of Vienna was held at the close of last month. The head-quarters were fixed in the Prater, where a quantity of reserve materials was collected. The strength of the detachment consisted of four field telegraph officials, who must be ready to act both as operators and clerks, one superintendent, twenty-three artificers of all kinds (from mere field labourers for setting up the poles to men competent to repair machinery), two waggons to serve as stations, and four waggons for the transport of materials. The station waggons resemble a wooden house; they are divided into compartments, and thoroughly fitted up for the reception of the instruments, &c. Two complete sets of instruments and other necessary furniture are allotted for each station, so as to be as independent as possible of accident, and an abundant supply of stationery, &c. The waggons for materials contain two (eight English) miles of copper wire, and a corresponding quantity of telegraph cable to be employed in marshy places or in crossing rivers, and a sufficient number of poles for supporting the wire at average distances of fifty paces. These poles are to be long enough to allow of the wire being carried at an average height of four mètres (about 13ft) above the ground.

ELECTRIC HEATING OF METALS IN VACUO.

Some results in connection with this subject have been recently described by Mr. Edison at the Saratoga meeting of the American Association for Advancement of Science. A platinum wire rendered incandescent by an electric current presents before long a shrunken appearance, and is full of deep cracks, and if the current be continued several hours these effects so increase that the wire falls to pieces. Now, Mr. Edison attributes these phenomena to expansion of the air in the pores of the platinum, and contraction on the escape of the air. He has aimed at letting the air out gradually and not explosively, and has succeeded in producing a metal "in a state hitherto unknown, and which is absolutely stable at a temperature where nearly all substances melt or are consumed; a metal which, though originally soft and pliable becomes as homogeneous as glass and as rigid as steel." His mode of procedure was this:—Several similar platinum spirals were brought to the melting point by means of an electric current, and the average light of each was then found, by the photometer, equal to four standard candles. Next, one spiral was placed in the receiver of an air-pump, and the air exhausted to 2mm.; a weak current was then sent through the wire to warm it slightly, and so assist the gradual escape of the air from the metal. The temperature was gradually increased (by increase of the current) at intervals of ten minutes, afterwards at intervals of fifteen minutes. Before each increase the wire was let cool, and a welding process occurred in it at the points previously containing air. In one hour and 40 minutes the spiral had reached such a temperature before melting that it was giving a light of 25 standard candles, whereas, by the other process, it would certainly have melted before giving a light of five candles. Several more spirals were tried, and with like results; one, brought to a high temperature more slowly, gave a light equal to 30 candles. The radiating surface of the spirals was 3 1-16in. On microscopic examination of these spirals no cracks were visible. The wire had become white as silver, polished, smaller in diameter, very difficult to melt in the oxyhydrogen flame, as hard as the steel wire of pianos, and incapable of annealing at any temperature. Mr. Edison is convinced that what is known as annealing of metals to make them soft is simply cracking of the metal. Annealed wire showed in the microscope myriads of cracks. By reason of the increased capacity of platinum to withstand high temperatures, it is possible to employ small radiating surfaces, and thus reduce the energy required. Mr. Edison says he can now obtain eight separate jets, each giving out an absolutely steady light, and each equal to 16 standard candles, or a total of 128 candles, by the expenditure of less than one-horse power. In his paper he describes some effects got from other metals treated in the way above mentioned.

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CONTACT THEORY OF VOLTAIC ACTION.

Parts I and II.

By W. E. Ayrton and John Perry, Professors in the Imperial College of Engineering, Tokio, Japan.

(continued from p. 196).

Part II.

ON A METALLIC VOLTAIC CELL, AND ON ELECTROLYTES OF GREAT RESISTANCE.

When any two pure insulated substances A and B are placed in contact with one another, the electromotive force of contact $\overline{AB}$ charges them to a certain difference of potentials which is numerically equal to $\overline{AB}$, and these charges of electricity represent a certain amount of energy of which the equivalent is a definite amount of chemical action. If the substances are pure, there is no other electromotive force that can disturb this establishment of charge. It is probable that the chemical action which might occur at the surface of contact is very little diminished by this charging, and we have no right to say that the total amount of possible chemical action at the contact of two metallic surfaces is simply equivalent to the energy of the charges. When A and B are solid, their rigidity limits the possible amount of chemical action; but even when they are both metals, if one is a liquid the total amount may be very considerable. With metals there is a limit produced by the want of mobility of the alloy, and when the liquid is not metallic there is a limit produced by the compound being insoluble, and so preventing free contact. After the charges are established the electromotive force of contact is exactly balanced, and there is no further action of any kind. If, however, A or B be a non-conductor, this establishment of charge may take a considerable time. In any case there can only be an exceedingly small amount of chemical action between any two *pure* substances, as, for example, pure zinc and pure sulphuric acid.

If A, B, and C be any three substances insulated from other bodies, A and C being each in contact with B, but not in contact with each other, the electromotive forces of contact $\overline{AB}$ and $\overline{BC}$ charge the three bodies in such a way that the difference of potentials between A and B is equal and opposite to $\overline{AB}$, and the difference of potentials between B and C is equal and opposite to $\overline{BC}$. The energy required to produce this charging of the bodies is due to chemical action at the places of contact. After the three bodies are so charged there cannot be any further chemical action, and the total amount of possible chemical action at these places of contact is very little diminished by the charging.

Primâ facie we cannot compare the present difference of potentials between A and C with the electromotive force of contact that would exist between A and C were they brought together.

The establishment of the above differences of potential takes a shorter or longer time, as the bodies are more or less conducting.

If now we imagine A and C to be brought into contact, as we do not know the value of $\overline{AC}$, we cannot predict the amount of disturbance produced in the charges of A, B, and C; but we may assume that some disturbance is produced—that is, a current of electricity flows in the circuit. We can also say that, after the possible chemical energy at the various junctions is exhausted, as well as the potential energy equivalent to bringing A and C in contact, then, if the temperature of the circuit is everywhere the same, there can be no further current, since there is no further supply of energy.

It is known that in a compound *solid* metallic circuit, which is everywhere at the same temperature, there is no continuous chemical action at the junctions, and consequently, by the law of conservation of energy, there cannot be a continuous current. Hence it has been usual to assume that if A, B, C of our second example are metals, solid or liquid, the difference of potentials between A and C just before being brought into contact is equal to $\overline{CA}$. Now, in the case of one of the metals, B, being a liquid, we have, by the experiment described further on, shown this assumption to be untrue; and we believe that even when the three metals are all solid, if one or more of them were rather non-conducting, and if the surfaces of contact were large, there would be obtained a result similar to that which we have obtained with solid electrolytes of high resistance. In the case of three ordinary solid metals of high conductivity, the experiment would be very difficult, if not impossible, to perform, owing to the previous exhaustion of the possible chemical action through want of perfect insulation of A and C from all substances other than B before being themselves put in contact. The experiments now about to be described, as well as those given in our last Paper, lead us to the conclusion that in *all cases* when A and C are brought into contact there will be a disturbance—in some cases, no doubt, only momentary—in the previous charges of A, B, and C.

A Metallic Voltaic Cell.

It may be known that when rods of zinc and copper are placed in mercury and connected with an electrometer no charge is observed. If known, this may have been regarded as a crucial test of the truth of the common theory of compound metallic circuits. Whether the zinc and copper are in contact outside the mercury or not, the amalgamation of the zinc appears to proceed at the same rate. Now, it seemed to us that in this case the impurities and great conductivity of the zinc, with the great liquidity of the amalgam and the close proximity of foreign particles to pure metal, caused the amalgamation to be produced by local action alone, so that the supply of available chemical energy for the production of a current from the zinc to the copper was exceedingly small; and we have no doubt that at low enough temperatures, when the amalgam loses its liquidity, such an arrangement becomes a simple voltaic cell. It was necessary for us to use, instead of zinc, a metal of which the amalgam is nearly solid at ordinary temperatures. On inquiry we found that magnesium was such a metal, and on the first trial we obtained a result corroborative of the above theory.

Strips of platinum and magnesium, metallically attached to the electrodes of the electrometer, were dipped into mercury, which was, perhaps, slightly impure from the presence of other metals, but which had previously been washed with distilled water, and then well dried. There was a sudden large deflection, the amount of which fluctuated very much afterwards, but which was always considerable and on the same side of the zero. On successive reversals of the electrometer key the deflections to right and left of zero were found to be nearly equal to one another. In a short time there seemed to be an increased steadiness in the amount of deflection. When the platinum and magnesium were short-circuited for some minutes, the deflection had decidedly increased in amount on renewed insulation, and this occurred after every short-circuiting. To determine the electromotive force of the arrangement, strips of platinum and magnesium, scraped very clean, were dipped into pure mercury which had previously been washed with distilled water, and well dried. The maximum electromotive force obtained was 1·56 volts—that is, about one and a half times the electromotive force of a Daniell's cell, the platinum corresponding with the copper plate in the Daniell's cell. It may be possible, by mechanical or other means, or by using another metal than magnesium, to give constancy to this arrangement; and as its internal resistance is extremely small, the cell may be of great practical use for the production of powerful currents. It may be remarked that, as an amalgam may be easily separated into its components by distillation, such a cell, by suitable arrangements, can be kept in action for an indefinite time.

We have examined a circuit composed of the metals, platinum, tin, and lead, and the coil of a galvanometer. On raising the temperature of the tin gradually we found that there was a current, and that it gradually increased. Rapid changes in the current were observable at the melting point of the tin, and there seemed to be a small electromotive force independent of thermo-electric effects. When the platinum and lead strips were connected with the electrometer, the deflections were found to be too small for decided conclusions to be drawn. We shall proceed, when time allows us, with the investigation of metallic voltaic cells.

(to be continued.)

CODE TELEGRAMS.

The following are the communications (addressed to *The Times*, and, with the exception of the last, published in that paper) referred to in the leading article of our present issue :—

"London, Sept. 3.

"Sir: I trust you will allow me to call attention through *The Times* to a very arbitrary and vexatious rule that has been adopted by the recent International Telegraph Convention. Section 8 is to the following effect :—'Proper names of persons and places in the text of code messages must be used only in their natural sense,' which I take to mean that if I tender such a message as 'Virginia ashore, Scilly,' it will pass without challenge if it signifies that a ship called Virginia has gone ashore on the Scilly Islands, but if I use the words 'Virginia, Scilly,' to convey a different meaning to my correspondent, as understood by our code, the message will be refused. The telegraph companies reply, 'Use ordinary words, then; for instance, if

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you say "virgin silly" you can make these words mean anything you choose.' This answer sounds very fine, but all words are not suitable for telegraph codes, and a merchant in a large and varied business can hardly find a sufficient number of words for his code if proper names are excluded. Most merchants also give the preference to proper names because if a word comes mutilated they can more easily guess as to what it should be. Consequently most, if not all, have proper names freely introduced into their codes in alphabetical order along with other words. Further, for the sake of distinctness and rapid reference, most large firms have gone to heavy expense in printing their codes—one firm, I am informed, has recently spent about £1,700 in this way; and now, for no sufficient reason we can imagine, we have all to go to the trouble, the annoyance, and the expense of rewriting and reprinting our codes, and perhaps having to go through the same process again three years hence.

"The telegraph companies disclaim all responsibility for the change, and apparently did not desire it. The change can hardly have been made for the purpose of worrying people, but there is no other reason apparent. If it costs more to telegraph 'Derby' than 'jolly,' or if it costs more to telegraph 'Derby' when I mean by it 'pigs are flat' than when I inform a friend of the result of the race, why not charge a little extra for it? But this system of meddling and muddling for no apparent end is quite insufferable, and is causing much indignation and irritation throughout the mercantile community connected with the East. I am told that the new rule was adopted at the instigation of a branch of our own Government. If this be so, it may yet be possible to get it rescinded, and I would suggest that those interested should address a strong and united remonstrance to the Government on the subject.

"I further beg to protest against the delegates meeting in private and settling such matters without giving the public who are affected by their decisions any opportunity of being heard.—Yours truly,

"MERCHANT."

"September 4.

"SIR: All connected with the Eastern trade will thank you for striking the key-note on the subject of our new and most irritating grievance, brought about by the alterations of rules sought to be established by the Telegraph Convention. The alterations proposed, more especially with regard to Clauses 8 and 23, are feeble in the extreme, and easily to be evaded, while the disgust expressed by all classes of the community will go far to the curtailing of all telegrams, and in the end prove that loss instead of gain will result to the telegraph companies concerned. Rule 8 (as explained by you in this morning's paper) is most objectionable, and will cause endless trouble and annoyance in re-arranging codes; but Rule 28, reducing the number of figures from five to three to be taken as one word, is open to even greater condemnation, besides adding to expense of telegrams.

"If it is necessary to increase the charge for messages, by all means let it be so, and raise the price per word; but why the telegraph companies should annoy us in this way and put us to still further expense in reprinting our codes, &c., passes understanding.

"Pray continue to use your powerful influence, and agitate until the new regulations are withdrawn, and receive the grateful thanks of

"ANOTHER MERCHANT."

"London, Sept. 5.

"SIR: The letters of 'Merchant' and 'Another Merchant' deal with a grievance which is causing great irritation among those connected with Eastern trade.

"They have had to accommodate their business arrangements to a highly artificial system of telegraphing, and the drafting of a code in any large house is a laborious operation which cannot be confided to any but the most experienced clerks. The cost of printing, heavy though it be, is a mere bagatelle compared with the labour of compilation.

"The trade cannot now be carried on without the use of codes, and probably nine out of every ten are made upon the principle of using English and foreign words to arbitrarily represent a given meaning, of which symbols a large proportion will be the proper names of persons and places.

"The announcement is now made that these cannot be allowed, consequently nearly all codes must be revised—probably reprinted. The whole community of merchants is thus fined a considerable sum, besides being subjected to great inconvenience, and, to add to the grievance, there is no permanence in the new arrangement. Three years hence another conference may in its wisdom devise other rules equally objectionable, rendering necessary another change of front.

"The Eastern Telegraph Company profess great regret at the alteration and throw the whole blame on the conference, but they are not credited with having made any effort to save their customers, who are in a mood to receive favourably any scheme which will introduce competition on their lines.

"So far as I know, there is no general wish to defraud the company of its legitimate gains. If rates are too low, let them be raised; but the public have a right to ask that they shall not be heavily fined every three years by a conference which does not even give them the opportunity of being heard before inflicting the fine.

"I am, Sir, your obedient servant,

"A SINGAPORE MERCHANT."

"London, September 5.

"To Messrs. Ralli Brothers.

"DEAR SIRS: The managing director, Sir James Anderson, who is now in Scotland, has forwarded to me a draft reply to your letter of August 28 last on the subject of proper names in code messages, and I beg to transmit it to you as follows:—

"'I am in no way surprised at the contents of your letter, and regret the inconvenience you must be subjected to in altering your extensive code.

"'When the subject was discussed, as it was again and again by the delegates in committee and in full conference, it was demonstrated that every language with the admixture of a few vowels thrown in among consonants admitted of the formation of thousands of words which might be alleged to be proper names, and necessarily the ignorance of the clerks at the receiving stations of many or most of the languages other than their own would not enable them to detect words which were manufactured and which never had an existence.

"'No doubt you are aware that systems of combinations of words in accordance with what is claimed as the philology of the language have grown to such an extent that a new system of telegraphic words has been built up, and this has been added to by words which are called proper names to such an extent that there was no alternative but to define what we considered was language, and exclude proper names, or throw the whole thing open and adopt a letter by letter tariff.

"'But it can be demonstrated that the least tariff which the administrations could adopt with a letter tariff would be a *minimum* of six or ten words, or groups of three letters; all below ten would be at the risk of the revenue of the administrations; and not one of the delegates was prepared to adopt a letter tariff.

"'My proposal to adopt a selection of 100,000 words is based upon the principle that as all code words are as regards three-fourths of their value to the advantage of the merchant, the companies had a right of some claim at least to say what kind of words they were prepared to transmit, and as 100,000 words will give half a million different shades of transactions in one, two, or three words to each transaction, it was generally considered at the conference that they were acting liberally, and at the desire of the companies eight languages were decided upon instead of the four and six, which had many supporters.

"'I do not know what the next five years may develop as to telegraphic language, but should it result in more combinations contrary to the usage or general use of the languages adopted, then I am of opinion that the next conference will have no alternative but to authorise a code, and make it obligatory, or throw the whole thing open and raise the tariff.

"'I cannot help believing that if any merchant had to consider the subject from our standpoint he would consider that we had acted rather more, indeed a great deal more, in the immediate interests of the merchants than of the shareholders. It can be proved that if all our customers used a code of 200,000 words, or even 100,000 words, our revenue would suffer so much that an increase of tariff would be indispensable.

"'As telegraphing is understood at present, the larger majority of our customers find 25,000 to 50,000 words enough for all their purposes. This fact, together with the 5 per cent. of customers who have had no code, enables us to wait patiently for the gradual development of traffic as the result of the word-tariff and the growing use of code language.

"'I do not believe the Eastern and Indo-European Companies would be listened to even if disposed to advocate any divergence from the rules of the recent conference. All the points referred to in your favour of the 28th ult. and every other point known to us were put before the conference for their consideration; and as they (the Government delegates) especially considered themselves the guardians of public interests they are not likely to rescind any rule so long and seriously considered as the prohibition of proper names.

"'It does not rest so exclusively with these two companies as you suppose. India, Java, Australia, Japan, the Great Northern Company, and all the nations from whom these companies hold concessions—viz., Russia, Turkey, Germany, France, Portugal, and Egypt—must be consulted, and I do not believe they would for one moment consider any change, nor permit us, upon pain of forfeiting our concessions, to make any exceptions outside the rules established.

"'I must, however, ask you only to accept these remarks as an individual opinion. Any initiative of any change whatever must rest with one of the signatories of the convention. The Post Office represents this country and all its telegraphic interests; and, properly speaking, all those matters should be referred to it for reply.

"'I have, however, desired to put before so influential a firm the points which I think tell against any possibility of the International Convention adopting proper names. It was, in fact, the abuse of proper names and the attempt to build up a telegraphic word system which brought forward the rules restricting and defining language for code purposes, and I can only regret that a firm such as Ralli Brothers, who support us so well, should be one of those who will, I suspect, suffer more inconvenience than almost any other firm from the restrictions adopted.'

"I am, dear Sirs, yours obediently,

"GEORGE DRAPER, Secretary,

"for Managing Director."

"SIR: Will you allow me a few words of comment on Sir James Anderson's reply to Messrs. Ralli Brothers, printed in *The Times* of to-day? I am grateful for the first public acknowledgment from the other side, that 'the use of code language must develop traffic.' We, the senders of code messages, have maintained this all along. I use a code, which I have not ceased to perfect from year to year, and the more perfect it becomes, the more money I spend into the telegraph treasuries.

"There is now no longer any question of suppressing codes, or charging double rates for code-words. That stand-point has become obsolete in the short time since the conference met at Rome. Now it is acknowledged that codes tend to increase traffic; yet the outcome of each conference seems to be rules which have the effect of retarding, or making more difficult the use of that 'code which develops traffic.' And these rules put no money into the telegraph treasuries; they only take it out of our pockets, and needlessly harass and annoy us, their best customers. For, if I may repeat what I stated in a letter to you after the Roman conference—let them make what rules they like, we shall adapt our codes to them.

Sir James Anderson says that the conference has thought it necessary to define what they consider language—*i.e.*, they have forbidden the use of proper names as code words. He does not, unfortunately, adduce any of the reasons which led the conference into this error. The perplexity of his 'ignorant receiving clerk' on receiving the word 'Schweinfurt' with a code meaning attached to it ignored by him, cannot be greater than when he receives the same word, when it only is intended to express the name of a prosperous and not euphonious town.

"The present word tariff can only be looked upon as a stage on the road to the only logical tariff—anyhow, for long lines—a letter tariff. A signaller should—the same as a setter of type—signal letters, without reference to the words or groups of which they may be parts; and, in point of fact, he does it. My code contains words of five languages, and has worked for years to my satisfaction, although the receiving clerks, at the other end are, as a rule, ignorant of four of those languages.

"An objection has been made that the arrangement of the telegraph instruments, or the telegraphic alphabet, do not lend themselves to the secure transmission of single letters or figures. If so, let the ingenuity of tele-

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graph engineers be set to work to invent arrangements in accordance with the wants of the age. We do not get a guarantee of correct transmission now, and we do not ask for it in future. If the letter tariff be impossible for the present, I am ready to give Sir James Anderson his *minimum* of six or ten groups, of not less than three nor more than five letters or figures, and pay for each group the price of the present 10-letter word. If this again is objected to, let us by all means have Sir James Anderson's 100,000 or 50,000 selected code-words, promised so long ago. Traffic will increase in proportion to cheapness of messages; and messages will be at the *maximum* of cheapness on the wires of companies, which (1) are based on a fair return for a capital unencumbered by promotion money, commissions, and the watering process; (2) will try to increase the transmitting power of the wires; and (3) will facilitate the use of codes in every way.

"Sir James Anderson writes and fights *pro domo*; I write in the interest of irrepressible progress. For cheap telegraphy means for me increased competition, and I have enough of it already. But I know that progress cannot be stopped because it reduces the earnings of an individual or the dividend of a company.

"I trust the meeting suggested in *The Times* of to-day will be convened and succeed not only in getting the elimination of proper names from codes rescinded, but in pushing forward the adoption of a letter tariff with all its consequences.

"Perhaps a standing committee might be formed, as a medium of communication between the telegraph authorities and their customers.

"I am, Sir, your obedient servant,

"Mincing-lane, Sept. 8. "CODEX."

"Sir: Referring to Rule 8 of the rules and regulations for transmission of telegrams on and after the 1st of April, 1880, which prohibits the use of proper names of persons and places as code-words, and which rule will probably necessitate the reprinting of nearly all the codes now in use, it would be a great boon to the public if the telegraph companies would themselves publish a list of code-words which they will allow to be used, and supply this list to their customers at a certain price. Otherwise, in going to the expense now of printing fresh codes, there is no guarantee that these, in turn, may not very soon be rendered useless by some fresh regulations.

"We are, Sir, your obedient servants,

"London, Sept. 18." "AUSTRALIAN MERCHANTS."

"Sir: Under the signature 'Australian Merchant' a writer in *The Times* of Saturday, referring to the International Telegraph Conference, suggests that, in order to provide a guarantee that new codes may not be rendered useless by fresh regulations, the companies should themselves publish a list of code words which they will allow to be used. The companies, however, cannot, without inviting criticism, collate, print, and publish codes any more than they can collect and supply news. They are merely carriers to convey the code words or the news handed to them for transmission; nor does it rest with the companies to 'allow' any code, for they must act under the stipulations of the convention between the States. Companies' codes, if formed, would not possess any authority or provide any guarantee against fresh regulations which merchants cannot ensure for themselves by observing the International Telegraph Convention of London. This convention gives coders eight languages out of which they may form their codes. Words culled from all these eight languages may be used in one and the same message, and, excluding proper names, the material thus available is far more than necessary. No fresh regulations can be made for five years, and consequently codes need undergo no alteration for that period.

"To prevent the necessity of any changes at the end of five years, the conditions of the convention should be properly observed. Fair dictionary words only should be used in constructing codes, and the ingenious efforts hitherto so conspicuous to combine several words in one and to build up lengthy combinations of syllabic sounds constituting no dictionary word in any known language should be abandoned. Words should not be chosen for their extreme length, because the *maximum* of ten letters was not intended to be transformed into the mean, as the word *maximum* denotes, but to prevent the too frequent recurrence in telegrams of exceptionally long words.

"If code-makers proceeded on these simple and equitable lines, there would in all probability be no interference with codes at the end of five years, when the next Telegraph Conference assembles, because there has been none, hitherto, except for the purpose of repressing growing abuses.

"The States parties to the convention may not care to continue struggling to preserve their conventions from circumvolation and their revenues from encroachment by code-makers, and may regard it as a more dignified and less troublesome course to prohibit the use of code altogether.

"The senders of messages consisting of plain language who do not ordinarily make use of the wires for purposes of gain have not yet been heard, but that over extra-European lines code is at present treated on a far more favoured footing than plain language is unquestionable, and a readjustment of tariffs in this direction, when practicable, would only rectify a glaring anomaly. "I am, Sir, your obedient servant,

"PLAIN LANGUAGE."

The following letter is in answer to representations made to Government in a sense adverse to the restriction adopted by the Conference:—

"India Office, 30th August, 1879.

"Gentlemen: I am directed by Viscount Cranbrook to acknowledge receipt of your letters of 11th and 27th inst., drawing attention to the resolution arrived at by the delegates to the recent Telegraph Conference, whereby words used as cyphers in extra-European telegraphs are to be restricted to words of eight specified languages, and the use of proper names as cyphers is to be prohibited, and requesting that his lordship will use his influence to prevent the final ratification of this provision in the New Convention.

"In reply I am to acquaint you that the rules to which you object were considered necessary in the interest of the public service, and that they had the support of all the extra-European delegates, and of the Submarine Telegraph companies.

"His lordship is unable, therefore, to throw any obstacles in the way of their ratification.

"I am, however, to point out that in order that merchants and others may be placed at as little inconvenience as possible, the strict enforcement of the new rules will not be made until the 1st July next.

"I am, gentlemen, your obedient servant,

(Signed) "LOUIS MALLET."

RECENT PATENTS.

65. Electric Lamps, *A. M. Clark.—Dated 6th January, 1879.—(A communication.)—(Not proceeded with.)* 4*d.*

The carbon or other pencil electrode is immersed in a column of mercury for the purpose of feeding it up as it is consumed.

83. Electric Lamps, *W. Ladd.—Dated 8th January, 1879.—(A communication.* 6*d.*

The holder of the lower carbon consists of a tube free to slide in vertical guides, and slotted longitudinally to admit a portion of the periphery of a grooved pulley, to which is attached a cord that depends therefrom into the tube and carries a weight. The weight when the cord is wound on to the pulley comes in contact with a stud projecting inwards from the tube, thus moving the holder upwards. Surrounding the lower part of the tube is a coil of copper wire, with one end in connection with the frame of the lamp and the other with the source of electricity. When the circuit is completed a current flows through this coil and causes it to act as a magnet upon the carbon holder. The upper carbon is secured in a pendant holder jointed to an arm carried by a vertical rod free to slide in a tubular socket fixed to the base frame of the lamp, but insulated therefrom. By the side of this socket is a mercury tube open at its upper end to receive a rod attached to the sliding rod, and which will dip into the mercury and maintain metallic contact with the tube whatever be the position of the carbon holder. A wire from the mercury tube connects with the electric source, and thus when the carbons are brought together causes a current to flow through the lamp. Keyed to the axle of the first pulley is a second pulley of twice the diameter, and connected to it is a cord attached to the sliding rod of the upper carbon, so that when the axle is turned by the action of the counterweight the two carbons are caused to approach each other. When the lower carbon is drawn down by the action of the coil, the upper carbon will simultaneously rise.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Sept. 24.		Business Done Week Ending Sept. 24. Highest.	Lowest.
Anglo-American Ordinary	53¼,	¾	53⅝	53⅜
Do. "B"	82,	½	82⅝	82
Do. "A"	27¼,	¾	27¾	27¼
Brazilian	6⅞,	7	7	6 15-16
Cuba	7¼,	¾	—	—
Do. Ten per Cent. Preference	15,	16	15⅝	15⅝
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	—	—
Direct United States	10⅜,	⅝	10⅝	10½
Eastern	7⅞,	8	8	7⅞
Do. Six per Cent. Debenture	104,	107	107	106½
Do. Five per Cent. do	101,	103	103	102
Do. Six per Cent. Preference	11 15-16,	12 1-16	12	12
Eastern Extension	7⅝,	8	8	7¾
Do. Six per Cent. Deb.	105,	108	107	106
German Union	7½,	8	—	—
Globe Telegraph and Trust	4⅞,	5	5	4⅞
Do. Six per Cent. Preference	11¼,	¾	11¾	11¼
Great Northern	8⅜,	⅝	8½	8½
Indo-European	21,	22	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9,	10	—	—
Submarine	224,	229	223	223
West India and Panama	1⅜,	⅝	1 5-16	1½
Do. Six per Cent. Preference	7½,	⅞	7⅝	7½
Western and Brazilian	2¾,	3	3	3
West. Union Seven per Ct. 1st Mt.	120,	105	—	—
Do. Six per Cent. Sterling	104,	106	105	104½

TRAFFIC RECEIPTS FOR AUGUST, 1879.

Companies.	Aug. 1879.	Aug. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,300	2,569	—	269
Direct Spanish Telegraph Company	980	879	101	—
Direct United States Telegraph Company	17,100	—	—	—
Eastern Telegraph Company	36,257	35,889	368	—
Eastern Extension Telegraph Company	26,242	24,870	1,372	—
Great Northern Telegraph Company	16,800	—	—	—
Submarine Telegraph Company	10,790	10,152	638	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—

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NOTES.

Cable Repairs.—The Singapore-Batavia cable is now repaired, restoring direct route to Java and Australia.

The West Coast of America Telegraph Company (Limited).—The traffic receipts for the month ending 31st July, 1879, were £1,350.

Western Union Telegraph Company.—The directors of the Western Union Telegraph Company announce a quarterly dividend of 1¾ per cent.

Artificial Magnets.—Dr. Gowin Knight, an English physician, was the discoverer of the method of making powerful magnets. The method was at first kept secret, but afterwards published by Dr. Wilson.

Indo-European Company.—The directors of the Indo-European Telegraph Company (Limited) have declared an interim dividend for the half year ending the 30th of June last at the rate of 5 per cent., free of income tax, payable after the 1st of October.

The Telephone Exchange.—The Edison Telephone Company has invited tenders for the laying of one or more wires connecting Manchester with Rochdale, Oldham, Ashton, Bolton, Bury, Middleton, Stalybridge, and Stockport, and for several miles of separate wires to be distributed about those towns.

The Eastern Extension, Australasia, and China Telegraph Company.—The directors of the Eastern Extention, Australasia, and China Telegraph Company (Limited) have declared an interim dividend for the quarter ending the 30th June last of 2s. 6d. per share, or at the rate of 5 per cent. per annum, free of income tax.

Eastern Telegraph Company.—The Company announces the payment of an interim dividend of 2s. 6d. per share on the ordinary shares of the Company for the quarter ended 30th June, 1879, and also a dividend of 3s. per share on the six per cent. preference shares for the quarter ended 30th September, 1879. The half-yearly interest on the six per cent. debentures will be paid on the 15th October.

Brown's Relay.—The information which reaches us concerning this relay is very satisfactory. Thus, for example, at Zaute, the relay has been working for a year on the busiest circuit (that of Otranto) with one sole regulation, the covering of the relay not having been removed during the entire period. We understand also that at Durban, on that portion of the Cape cable, the relay is giving excellent results.

Telegraphic Convention.—An Anglo-French telegraphic convention has been signed, whereby after the 1st of April next telegrams from any part of the one country to the other will be charged 20c. per word, without *minimum* as to length. M. Cochery is also negotiating for reduced rates with Italy, Spain, Belgium, and Switzerland. M. Gaudet has been despatched to London and Berlin to study the arrangements of post and telegraph offices.

Telegraph Word-Tariff.—On Wednesday the new tariff for telegrams came into force in Holland. For every telegram must be paid a standard price of 3d., added to which is one cent, or a fifth of a penny, for every word which the telegram contains. "Answer paid" will hold good for 10 words only; the letters R.P. (*réponse payée*) will be reckoned as one word. The new arrangement at present does not extend to any other countries than Holland and Belgium.

Hausteen's Magnetic Experiments.—It would be interesting to know whether the results obtained by Prof. Hausteen at Copenhagen have been corroborated by more recent experiments in the same place. In making experiments in the round tower at Copenhagen, 126ft. in height, he found that the magnetic intensity increased regularly towards the top, where it was a maximum, and that at the foot of the tower the needle oscillates quicker at the north side, and slower at the south side, whereas at the top the opposite case ruled.

Clamond's New Thermopile.—The workshops of M. Denayrouse have been experimentally lighted by means of the electric lamp of M. Suisse, worked by a thermo-electric battery constructed by M. Clamond. It is found that more than twice as much charcoal was consumed in heating this apparatus than would have been required to produce the same light by means of a dynamo-electric machine. On the other hand, only about 6 per cent. of the total quantity of heat produced was actually converted into electrical work; the remaining 94 per cent. being readily and conveniently available for heating and ventilating purposes. Moreover, it is considered quite practicable to economise one-third of the quantity of fuel which was used in the present experiment.

André's Electric Mining Lamp.—A number of gentlemen, including the Duke of Sutherland, Professor Keates, Chemist to the Metropolitan Board of Works and Mr. Easton C.E. attended at the offices of the British Electric Light Company in Parliament-street to witness George E. André's electric mining lamp in operation. Mr. André gave an explanation of the lamp and its working, and showed its adaptability to the lighting of fiery collieries and mines generally. The atmosphere being securely excluded from the light, the risk of explosion, with its fearfully disastrous effects, is entirely avoided, and this is attained advantageously and economically, for the light emitted is of great power, and the cost far less than that of safety lamps or candles. The Duke, on taking leave of Mr. André, expressed his satisfaction at the success attained, and remarked that the lamp had a great future before it. The lamp exhibited will burn six hundred hours in a mine without being touched, four carbons being thrown into light automatically one after another.

Ornaments with Motion Produced Electrically.—Some curious trinkets, to which certain motions can be given at will by means of electricity, have recently been devised by M. Trouvé. Two of these (described in *La Nature*) are scarfpins; one has a death's head, gold or enamel, with diamond eyes and an articulated jaw; the other has a rabbit seated upright on a box with a little bell before it, to be struck with two rods held in the animal's forepaws. An invisible wire connects these objects with a small hermetically closed battery, the ebonite case of which is about the size of a cigarette. It is kept in the waistcoat pocket, and acts only when turned horizontally or inverted. When a person looks

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at the pin the owner, slipping a finger into his pocket, moves the battery, whereupon the death's head rolls its eyes and grinds its teeth, or the little rabbit beats the bell with its rods (through electro-magnetic action). A third kind of ornament is a small bird set with diamonds, to be fixed in a lady's hair, and the wings of which can be set in motion electrically.

The Electric Light at a Distance.—An interesting and somewhat important experiment was recently carried out at Saratoga Springs, New York, for testing the extent of the illuminating power of the Maxim Electric Light, and if the particulars are only approximately correct, the results are eminently encouraging. It appears that the light was put in operation on the tower of the Grand Union Hotel. An open parabolic reflector was used—no lenses—and care was taken by Mr. Maxim to set the points of the carbons a little on one side of each other, and to adjust them exactly to the focus of the reflector. This having been accomplished, the light was turned toward a spot in Ballston Spa, New York, seven and a half miles distant, where, by previous arrangement, a group of several hundred persons were assembled to witness the experiment, with the result, as we are informed, that the place was instantly illuminated in such a way that ordinary print could be read, the time seen on watches, &c. The night, it is stated, was clear, still, and dark. The experiment was made at about half-past nine o'clock in the evening.

. Statistics of the Electric Light.—At a meeting of the Association of Municipal and Sanitary Engineers, Mr. Deacon, of Liverpool, in the chair, said as he had not anticipated that he should be asked to take it, he was not prepared with a presidential address. Mr. James Shoolbred, B.A., read a paper on electric lighting and its application to public illumination by municipal and other bodies. Dealing first with the question of expense, he gave estimates showing that under three electric light systems, the Gramme A machine, the Siemens' medium machine with the small-sized Siemens' lamp, and the Jablochkoff system, besides the first outlay, the working expenses per hour of the system first named were for one light, 1s. 6d.; for two lights, 2s. 1d.; for three lights, 2s. 7d.; and for five lights, 3s. per hour. For the second, 1s. 7½d., 2s. 4d., 2s. 10d., and 3s. 9d.; and for the third, for six lights, 2s. 5d., and for 20 lights, 5s. 5d. per hour. Another point discussed in the paper was as to the wholesomeness and pleasantness of the electric light as compared with gas light. The electric light gave off nitrous acid, and gas gave off sulphurous acid, both of which were objectionable in almost the same degree; but by experiment it had been shown that only about five grains of nitrous acid were given off in one hour by the electric light, with an illuminating power of 1,000 standard candles, whereas 20 grains of sulphurous acid were the result of the combustion of 100 cubic feet of gas, the illuminating value of which would be four standard candles.

Supposed New Applications of the Induction Coil.—A correspondent of our contemporary, *l'Electricité*, contributes to that journal drawings and descriptions of two devices by which he assumes that starlings or other small birds may be destroyed or captured, and grape vines cleared of the destructive *philloxera*. In one of them the upper branches of a tree are coiled with copper wire, on which, by means of decoys, the birds are induced to perch. A *chasseur* concealed at a distance then completes the circuit of an induction coil through the aforesaid wire, when the birds are said to fall down *foudroyés*, or lightning-struck. In the other plan, wires in connection with the secondary coil are brought into contact with the vines, through which a series of discharges are passed with a view of destroying all insect life. Unfortunately, the former plan would be entirely inefficacious; the circuit being completed, not through the birds but through the tree. The writer is under a grave misapprehension in regard to the birds, very sensitive, he says, to the action of voltaic electricity, which are frequently found dead in the vicinity of telegraph wires. These are not, as he supposes, *foudroyés* by the current from the signalling station; but have maimed, or killed themselves outright, by flying violently against the wires. In the other plan, also, the circuit is completed through the unfortunate plants; but it is possible that derived currents through the insects located upon them may prove fatal to these destructive pests. We should, however, have great fears for the plants themselves, especially if the conductivity of the secondary circuit were augmented by watering the roots of the vines with metallic solutions, as is recommended by the author of the suggestions in question.

The Aurora Borealis.—The following letter, by Mr. G. T. Temple, is given in this month's "Proceedings of the Royal Geographical Society":—"Although the conjecture hazarded more than 160 years since by Halley, that the Aurora Borealis was a magnetic phenomenon, has acquired empirical certainty from Faraday's discovery of the evolution of light by magnetic forces, as well as from more recent observations, the following extracts, translated from a letter written by Herr Pastor emeritus H. M. F. Esmark, may perhaps be considered interesting, Herr Esmark having observed the meteorological conditions attending the display of the polar lights for many successive years:—'The aurora is neither seen during extreme cold or northerly winds, but appears when an ordinary Arctic temperature is raised by southerly and westerly winds, and is generally followed by snow. In the south-eastern part of Norway it seems to be especially caused by south-easterly winds, which are there very moist and rather warm. Its appearance is always accompanied by a falling barometer. In my opinion the phenomenon is due to the following causes:—When a wind laden with warmth, moisture, and electricity comes in contact with a body of cold air, the moisture is converted into snow, the warmth and electricity are thereby released, and the Aurora is the result of the disturbances. The northern lights cannot occur in very high latitudes, because the warm, moist air is cooled long before it reaches them.' In this way Herr Esmark would account for the splendid appearance of the Aurora in Northern Norway, where the sea winds, bringing warmth, moisture, and electricity from the ocean, are met by cold land winds from the interior. MM. Lottin, Bravais, and Siljerström, who spent a winter at Bosekop, in Alten (lat. 70° N.), saw the northern lights 160 times in 210 nights. The most vivid Aurora that I ever saw near Alten was towards midnight on the 12th of November, 1874. The flickering lights played about the mast-head so like lightning that it was difficult to believe they were harmless. We had no snow, however, till the evening of the 14th, as we were entering Tromsö Harbour, and during the discharges of light, the compass-needle was wildly erratic. The determination of the chemical elements involved by means of spectrum analysis is by no means the least of the numerous scientific results to be derived from Arctic exploration."

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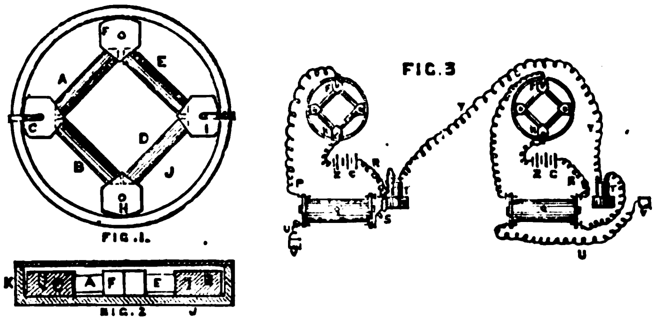
CROSSLEY'S COMPOUND MICROPHONES.

The improvements of Mr. Crossley consist in employing a compound microphone in conjunction with a telephone, for the purpose of conveying sounds, by which means an increase of intensity of sound is produced, conveying faithful, plain, and distinct messages.

His microphones have three, four, or more pencils, and six, eight, or more surfaces touching each other, by which means the resistance of the circuit is varied, and whether arranged with pencils or of any other form, the compound microphone is mounted or fitted by preference on a wood diaphragm. He finds pine wood to answer well, but the microphone may be mounted or fitted on a parchment diaphragm, which is stretched or fixed over the top of a drum, and diaphragms of any suitable kind of substance may be employed. The compound microphone, when mounted or fitted on a diaphragm, is connected with a battery and induction coil in such a manner that any variations in the resistance of the compound microphone caused by sound waves effects a corresponding alteration in the strength of the current of electricity flowing through the compound microphone and induction coil. This variation again causes a variation in the current induced in the induction coil connected to a telegraph line, which causes corresponding currents to flow through the telegraph wires, and by attaching a telephone to the distant end of the telegraph wires, the messages are conveyed with great distinctness.



The instrument will be better understood from the diagrams. Fig. 1 represents a plan of a compound microphone having four pencils, eight surfaces, and four carbon blocks, the microphone being mounted on a wood diaphragm; Fig. 2 is a sectional elevation of the same; Fig. 3 represents the joining up between two stations with compound microphones and telephones connected in circuit with batteries and induction coils.

As stated above, Figs. 1 and 2 represent a compound microphone in which four pencils of carbon, A, B, D, E, are held loosely in four carbon blocks, F, G, H, I; the microphone is mounted by preference upon a piece of wood or diaphragm, J, and pine wood is found, under certain circumstances, to answer well, and to produce better articulation than other kinds of wood when used for this purpose; the microphone is enclosed by a wooden rim, K, and a cover, L, may be fitted over the top of the rim, and made by preference of thin wood, or the microphone may be left open.

The compound microphone can be constructed without carbon pencils, which can be replaced by other suitable substances capable of varying the resistance of an electric circuit in a similar manner to the pencils and carbon blocks.

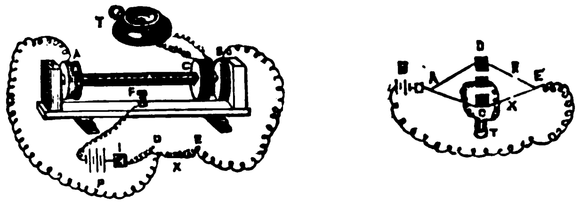
The compound microphones, having a greater number of vibrating points, and consequently a greater number of points in which the resistance of the circuit is varied, produce louder and more distinct articulated sounds, and are not liable to get out of adjustment like the microphones heretofore employed in which the articulation is frequently imperfect.

Fig. 3 represents the joining up between two stations of compound microphones and telephones connected in circuit with batteries and induction coils, and for simplicity the switches for bringing the alarm and other parts into circuit are not shown; the plan shows the instruments joined up between two stations, W and X; one of the carbon blocks H of each station is connected with a battery, Z C, and the blocks F are connected with the primary wires P of the induction coils Q, the other ends are connected by wires, R, to the batteries Z C, and the sides of the secondary wires are connected by electrical wires, S, to a telephone, T, and the other ends of the secondary wires U to earth, V, or to return wires. The telephones T are connected by means of the line Y.

THE TELEPHONE USED TO MEASURE RESISTANCES.

M. E. Hospitalier, in *La Lumière Electrique*, describes two methods by means of which resistances can be accurately measured without the aid of a galvanometer.

Let A C E D represent the terminals of a Wheatstone's Bridge. Insert a battery and contact breaker—or we would suggest a microphone—between A and E. At D insert a coil in circuit A D E. At C insert a similar coil in circuit A C E. Between the coil at D and the coil at C place another coil, consisting of smaller-sized wire, the two ends of which are to be connected to the terminals of a telephone, T. Let R represent a box of resistance coils, and X the unknown resistance to be measured.



If contact is made, and a current passes from A to E, the coils at D and C act inductively and oppositely on the coil between them, and if a sound is produced, either by means of the microphone or rapid contact breaker, a sound will be heard in the telephone, provided the resistances R and X are unequal. The resistance R has to be adjusted till no sound is heard. Then the resistance unplugged is equal to the unknown resistance. It will be seen that this method is a null method; but we cannot altogether agree with the author, who says:—"Cette méthode revient donc à égaliser deux courants ou plutôt deux résistances et à apprécier cette égalité par le téléphone, qui est, comme on le sait, l'appareil électrique que le plus sensible qui existe." Is it proved that the ear is on the average more sensitive than the eye? The sensitiveness of the method depends on this, and we doubt if the personal equation will not be as great when no sound is the limit as when zero on the galvanometer scale is the limit. This comment, of course, in no way militates against the ingenious method devised by M. Hospitalier.

LITERATURE.

Electric Transmission of Power. By Paget Higgs, LL.D., D.S.C. [London: E. and F. N. Spon.]

The utilisation of the natural sources of power to a greater extent than at present is one of the problems of the immediate future. Prof. Ayrton's lecture at the late Sheffield meeting of the British Association, shows how great a part electrical apparatus is destined to play in this direction, and Dr. Higgs must be congratulated in having given us this little work at so opportune a moment. The author in the first place describes the principal dynamo-electric machines, such as the Gramme, Brush, Wallace-Farmer, and Siemens, the description being aided by a number of illustrations. He then discusses Dr. Hopkinson's measurements as to the efficiency of such machines, and the statements of Dr. Siemens, Mr. Sprague, Messrs. Houston and Thomson, and Sir W. Thomson, on the practicability of transmission of power by electrical apparatus. Most of the papers of these gentlemen have from time to time been given in our columns, and hence their deductions are presumably well-known to our readers. Dr. Higgs refers to his own paper, read before the Institute of Civil Engineers, on the "Efficiency of Coupled Machines," and of necessity dwells at some length in Chap. VIII. on the report to the Franklin Institute, as well as to Mr. Desmond Fitz-Gerald's formulæ, which we originally published. The greatest tribute we can pay to this little work, to show our appreciation of its value, is to quote in full the author's conclusions. He says:—

"The feasibility of electric transmission of power having been proved from consideration of mechanical efficiency, both as regards current developed from mechanical power and as mechanical power reclaimed from the current thus produced, we have learnt from unimpeachable evidence that the power reclaimed may easily amount to 48 per cent. of that expended in the first instance. This amount of reclaimed power is indubitably supe-

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rior to that obtained with compressed air, and approaches the practical efficiency of hydraulic transmission. Electric transmission has, however, the unparalleled advantage of being superior to the obstacle presented by distance, whilst it is at the same time easily portable, and can be changed in direction, as well as in intensity, at will. No force appears in the connecting portions or conductor, such as appears during mechanical transmission with shafting, or in pipes with compressed air or water. The conductor appears inert, and can be shifted, bent, or in any way moved whilst transmitting many horse-power. Its continuity must not, of course, be interrupted.

"The source of power and the point of reclamation may be relatively situated most awkwardly, but the electric conductor can be brought round the sharpest corner, or carried through the most private room without inconvenience. There is nothing to burst or give way. The same circuit as may be tapped to provide the means of working power-machinery can be as conveniently tapped to work a sewing machine.

"In mining operations, electric transmission will doubtless become of the highest value, since it involves no danger. Machines for this purpose could be easily constructed without a commutator, so that sparks could be avoided, with only small loss of power. The ready portability offers great inducements to the mining engineer. For ploughing by power, trials made in France show that electricity can replace steam with advantage and economy. And, in Scotland, power obtained from a waterfall has been transmitted one mile and a half.

"Dredges could be reduced in size, and worked from a central motor, so that smaller channels could be cleansed mechanically than are now subject to this method. In mills and factories inaccessible rooms can be utilised for power-worked machinery. These are but a few advantages. A millenium might be anticipated when the water-power of a country shall be available at every door, for electric-power conductors can be laid in the streets more easily than gas or water-pipes.

"But, says the economist, what about cost? Acknowledging these great advantages, what is there to pay for them? And the economist can be satisfactorily answered. Leaving out of count the scheme proposed by Sir William Thomson, in which we might have our water conveyed to us through pipes, the metal of which conducted the electricity for our power, we have to consider what is necessary in transmitting power electrically.

"First, we require to generate our electricity, and water-power is, of course, preferable if available. If not available to generate electricity, it surely will not be available to compress air or force water, because these are only to be carried through comparatively short distances, and the original power question may be cancelled from the equation as being a common element. Reference, it need scarcely be said, is made only to cases where distance is involved. As our efficiency is good, we have only to consider (1) the cost of the motor and moved engines, and (2) the cost of the conducting systems.

"The motor and moved engines being in practice identical, the consideration of one suffices for both. These machines, as has been shown, are very simple in construction, and consist essentially of so much cast-iron, and insulated copper wire, the market prices of which are known, so that the cost of any machine for developing so much horse-power may be easily calculated. The labour of construction *should* form an unimportant item, for none of the skill is involved such as is required in the construction of even the most common steam, air, or gas engine. The quantities of materials required are but little, if more, costly, in the case of electric machines, and this excess of cost is due to infrequency of demand. The construction of machines of size hitherto unattempted is not required, and it has been shown by Prof. Thomson that electric machines of 1,000 HP., as proposed by Dr. Siemens, are not necessary, so that there would be no need to attempt to refute the question of cost of so unusually large-sized engine as of that Mr. Sprague has entered into. It has been shown that ten 100 HP. engines would give better results as regards efficiency, whilst at the same time it would be nearly impossible that all the machines could fall out of repair simultaneously.

"The arrangements of machines being thus consonant with the use of a small conductor, as shown in the previous pages, there is the further advantage in laying this conductor, that no air or water-tight joints have to be made. Taking such joints into consideration, it would be easy to show by figures that an efficiently insulated electric conductor to *transmit the same power* could be laid at *less* cost than with air or water, and certainly less than with gas pipes.

"The advantages of electric transmission, it is to be hoped, are worthy therefore of the attention of every engineer interested in transmitting power."

PIONEERS IN TELEGRAPHY.

A correspondent in the *English Mechanic*, having referred to early telegraphists, was requested by Mr. Latimer Clark to give some information on the subject. This request led to the following interesting letter, which we reprint from our contemporary. J. W. W. may be recognised in J. W. Wilkins. The second letter, by C. Tomlinson, F.R.S., was originally contributed to the *Salisbury Journal*:—

No. I.—EARLY HISTORY OF THE TELEGRAPH.

I have very great pleasure in acceding to Mr. Latimer Clark's request that I should afford some additional information with reference to the earlier days of the electric telegraph in this country, and I beg to add that I think it will be a welcome addition to the "Lives of Eminent Men" when the public have before them a "short account of the life and labours of Sir Wm. Fothergill Cooke." The "little band" to whom I alluded in my former letter included, at the date of the opening of the Northampton and Peterborough Railway Telegraph, Messrs. Cooke and Wheatstone; Robert Reid, the instrument maker; Mr. Favel, a nephew of Mr. Cooke's, and probably the earliest *employé* of all; H. Wainwright, carpenter; Mr. W. H. Hatcher, J. W. Wilkins, J. Braithwaite, and Fergusson Joseph, all named in the order of their engaging in telegraph operations, and of whom, I believe, I am the only one remaining. The occupations of the first three persons are plain. Mr. Favel had charge of stores and the erection of lines with the assistance of Wainwright; Mr. Hatcher assisted Mr. Cooke in the official direction, including some general duties of engineer, secretary, and manager; Mr. Wilkins had outdoor superintendence of telegraphs, assisted by Mr. Joseph, and Braithwaite was recognised as an operator. Up to the commencement of the works for the telegraph on the Northampton and Peterborough Railway in March, 1845, existing lines consisted of the London and Blackwall, the South Western (Admiralty line), a short single line of single rail, branch of the "Eastern Counties," and the line from Paddington to Slough, exhibited at 1s. per person, and which became famous for being the means of the immediate apprehension of Tawell the murderer. From this time, or rather from the date of the completion of the line to Peterborough, it would be necessary to consult the records of Mr. Hatcher's office some months before the inauguration of the "Electric Telegraph Company," for accurate information, as the introduction of the telegraph was now so rapid as to preclude the possibility of one's keeping pace with the development without he had duties in the London office. The Trent Valley line, however, was begun soon after the completion of the Peterborough line, and the wires were pushed on rapidly to Normanton and York, with one extension to Birmingham, and another in 1846 to Hull. About this time the Preston and Wyre line was put up, and the Woodhead Tunnel on the Manchester and Sheffield Railway was also furnished with the telegraph. The earlier months of '46 saw Darlington and Newcastle included in the Midland circuit, and before the first half of the year was gone Sheffield was connected and Berwick was reached.

It was not until the following year, 1847, that Birmingham, and also Liverpool, were connected with London. The reason for this delay was that both the London and Birmingham and Great Western Companies made opposition to the erection of the telegraph on their lines; the latter upon the advice of Brunel to wait for further improvements in the mode of signalling and advocating underground wires with dial (letter-indicating) instruments similar to Wheatstone's, which was exhibited side by side with Cooke's double-needle instrument at Paddington-station. The London and Birmingham Company held back through the influence brought to bear by friends of other electricians and telegraph inventors, in the expectation that there would shortly appear a better telegraph than that of the Electric Telegraph Company. This hope not being realised, the Railway Company were unable longer to hold out against the increasing popularity and evident practicability and usefulness of Cooke and Wheatstone's telegraph, and the line to London was the result. Mr. Wm. Highton was appointed electric telegraph engineer to the London and Birmingham Company in January, 1846, and I received a letter from Mr Cooke informing me of the fact, and desiring me to give up charge to Mr. Highton on his application.

With reference to the dates at which certain offices were established—I can only inform Mr. Clark that Mr. Cooke retained his old place of business at Copthall-court until late in 1845, and Mr. Hatcher his—the actual business office—on the second floor of a house at the bottom (east side) of Villiers-street, Strand, up to the end of that year also. The "Strand office" was evidently entered on late in the same year. I cannot tell the month, but having had business with the Villiers-street office up to November, and afterwards receiving letters from Mr. Cooke, dated from 345, Strand, in January, 1846, I should suppose it to be November or Dec., 1845. The Seymour-street house was taken on lease in 1846, and Founders'-court, Lothbury, was, I believe, occupied in the latter part of 1847.

Of Mr. Cooke's personal history I know but little; but one thing he told me, differing somewhat from reports I have heard and seen, was that he was practising anatomical modelling in wax at (if I remember rightly) Heidelberg; and it was in the theatre of the institution where he was working that he saw Oersted's experiment of the deflection of a magnet by a current of electricity passing through a wire in its vicinity. After serious consideration, which I am under the impression he said occupied three months, he determined to give up the pursuit of his profession, and devote himself entirely to the perfection of a telegraph, which from the first and for several years after took the form of a *five-needle instrument*. I have heard Mr. Cooke also say that his association with Professor Wheatstone arose rather from overtures on the part of the Professor's friends, who saw an advantage to both parties in co-operation, although the directions in which they were working were so different. Mr. Cooke believed that the Professor was the better-known man, and that it would further his own views with reference to needle telegraphs if he joined him, and, to use his own words, "as far as benefit was to be derived it was six for one and half a dozen for the other."

I hope I may be excused if I take the opportunity this time of expressing the satisfaction I feel at the part I played in the early introduction of the telegraph in England. I consider myself the first who ever took sole charge of a line of telegraph erected either for railway or commercial purposes, which I did on the 1st of July, 1845. Other lines there were: the

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Admiralty (South-Western) line, a branch line of the "Eastern Counties," worked solely for train signals, "stop," "go on," "line clear," "line blocked," &c., with four wires and four pointers at each station, and an extra wire for bell; the "London and Blackwall" for rope engine signals; and the line from Paddington to Slough. But all these lines were left to take care of themselves, and when any serious disarrangement occurred, and assistance was required and applied for, it was afforded as soon as convenient. This assistance generally consisted in Reed's workmen being sent, or the presence of anyone employed by Mr. Cooke (oft-times himself), as they might be at liberty, and in the neighbourhood. It was not until the London and Birmingham Company obtained the Act for the construction of the Peterborough line with a telegraph that it was thought necessary for anyone to devote his whole time to the maintenance of any special line of telegraph.

I had the honour of accompanying Mr. Cooke two days before the public opening of the Northampton and Peterborough line to take charge of the telegraph erected on it. On arriving at Northampton, and after connecting up the instrument there and leaving Mr. Braithwaite there, Mr. Cooke and myself went forwarded with other instruments to Wellingborough, Irthlingborough, and Thrapstone, arriving at the Wansford station the same evening after having connected up and communicated with Northampton from each station as we arrived at it during the day. On the following morning—the day before the opening of the line to the public—on going to the telegraph office at Wansford, we found that one of the two wires forward to Peterborough had no "earth" in that direction, and, supposing that some temporary disconnection only had occurred at the station ahead, we started off with the remaining instrument. Our consternation may be imagined when we found, on arriving at Peterborough, that the fault consisted in some break in the connection of the *line itself* in the seven miles between Wansford and Peterborough. No time was to be lost, and Mr. Cooke sallied out along the line, "detector" in hand, to find out the fault. The result was quite a new experience for us (and such were often occurring), for we found that, instead of a wire being broken, as was supposed, it had gradually lost its power of conducting the current; and it was evident that it could not be remedied in time for the opening train on the morrow.

The single needle had been in use as a "detector" for a long time, but never yet as a means of alphabetic communication; but, fortunately, some weeks before our expedition to Northampton and Peterborough, Mr. Cooke and I sat down at Copthall-court, and there concocted the signals now well known as the single needle alphabet, which we practised subsequently as often as we met at Reed's.

We had a pair of such "detectors" with us which had been made expressly for service on the N. and P. line, and to be used as single needle telegraphs if necessary. The earlier *employés* of the E. T. Co. will remember these very instruments being exhibited in the show-room of the Strand office some time after. They consisted of polished oaken cases about a foot in height, by four inches square, with silvered instead of the usual brasswork inside, silvered dials with the signs of the alphabet engraved and filled in with red wax on each side of the needle, and under all the following, "W. F. COOKE, INVENIT., 1845," and it was by means of these instruments that we were able to communicate between Wansford and Peterborough from different points of the line-wire on this occasion.

The construction of our lines then consisted in winding up the wires at each quarter-mile post, on small ratchet wheels, about two inches in diameter, and in seven miles there were fifty-six of them, each having a thick coat of paint which manifestly ought not to have touched the ratchet wheels, but which not only did so but in several instances filled up the hole through which the wire had to pass before being wound up. To disconnect the wires and to clean all the wheels was a work of time, and could not possibly be completed before the opening of the line.

On the arrival of the directors at Northampton the next day, Mr. Cooke telegraphed, as was supposed, to Peterborough (really only to Wansford), and communication was kept up from Wansford to Peterborough by single needle, with a gentleman who mastered it in a few hours, in time to enable us to carry on the pardonable deception.

I will say that the many difficulties which beset the earlier workers of the electric telegraph, and caused them inconceivable anxieties, can hardly be estimated nowadays. The break in the connection between Peterborough and Wansford led to the examination of every winder to Northampton, and to cause every ratchet-wheel connection to be made bright, which resulted in a manifest improvement in the continuity of the conductor. It may be imagined what sort of difficulties we sometimes laboured under in this way, as this sort of thing had never before been suspected, because continuity of the suspended conductor had never yet been quite broken, and extra battery-power was always at hand to overcome the increased resistance or loss of current, to which we are constantly subject. It was not suspected either, until my charge of the London and Birmingham portion of the Liverpool telegraph in 1867, that the iron winder-rod, in passing through the posts from side to side through earthenware collars, was sometimes surrounded by as much as half a pint of rain-water, making an "earth" through the post at that point. No doubt it was the multiplication of these "earths" that was the cause of the loss of current in wet weather on the wires of almost all the then existing lines; and it is a fact that on the "South-Western" (Admiralty) line a rain of a half day's duration, and not extending over more than half of the line, would as effectually prevent the passage of a current of electricity from Nine Elms to Gosport as ever a fog in the atmosphere did prevent the observance of semaphore signals.

I had reference to the recurrence of such troubles as these when I said in my last letter upon this subject that the "experimental telegraph" was *struggling* with the semaphore for supremacy.

With the insulation, too, of those early days the three miles and two chains length of the Woodhead tunnel, on the Manchester and Sheffield line, gave out completely after a month's working, so that no battery power at all would force it until I had reconstructed it; and a wet tunnel just before arriving at Gateshead (Newcastle), from York, made it (until the advent of gutta percha and improved methods of suspending the wires) always difficult to read signals at York from Newcastle.

How completely all this has been altered since those days can hardly be suspected by more modern telegraphists; nor can it now be fairly understood what a relief in signalling by needle was effected—or what a change was made in the sluggish long needle telegraphing by the quicker movement of the short lozenge-shaped magnet on its introduction by Mr. N. J. Holmes, chief of the instrument department of the Electric Telegraph Company.

I fear that I have already tried your patience with this letter; but I cannot close without correcting one error which Mr. Clark has naturally fallen into from my last, as to the date at which the Electric Telegraph Company's instruments were working "side by side" with the levers of the old semaphores. The Admiralty messages were transmitted by electricity from Nine Elms to Gosport only until 1846, when, as I have already stated, the wires at Nine Elms were connected underground (swathed in cotton, thread, tape, and spun yard, and coated with pitch-tar and resin, and all together inclosed in a leaden tube, which, by the bye, did not keep up the insulation over a month) with the Strand office, and thence to the Admiralty. The struggle I have before referred to consisted—beside what I have said about the miserable insulation—in the race between the message transmitted from the Admiralty in Parliament-street to Portsmouth, and the same message by the electric telegraph, the latter having first to be carried by hand to the Nine Elms station, and sent thence to Gosport by electricity, to be carried on its arrival there over the water by the ferry-boat to Portsmouth Dockyard. Instead, then, of 35 years ago, and 1844, as Mr. Clark supposes, it was 33 years, and 1846.

If Mr. Clark should wish any further information that I can render him, I shall be glad do so through your columns, or I would communicate with him privately if he would advertise his address in the usual way.

J. W. W.

No. II.—WILLIAM HENRY HATCHER.

One of the best and most talented men of whom Salisbury has reason to be proud has just passed away at the comparatively early age of fifty-eight.

There are probably but very few persons left among us who remember Mr. Hatcher's father and his school in Endless-street; and still fewer who remember him as the secretary and amanuensis of Canon Coxe, whose historical writings were held in great repute during the reign of George III. Mr. Hatcher was also himself an author of local history, as well as an accomplished scholar.

His only son, the subject of this sketch, thus had unusual advantages in his early training; but his intellectual bent was so decidedly in favour of science that his father yielded to it; and in order to give him the best education then possible, he placed him in the school of King's College, London, from which he matriculated into the college in the department of applied sciences, and became the favourite pupil of such distinguished professors as Daniell in chemistry, Moseley in physics, Cowper in construction, Wheatstone in experimental science, &c.

Hatcher assisted in some of the early experiments on the electric telegraph which were carried on at King's College; and when, by a singular accident, the electric telegraph suddenly became popular, Hatcher was its first engineer. It will be remembered that an experimental line had been laid down on the Great Western Railway from London to Slough; but it was scarcely used, and the Government would not adopt its principle, preferring the old system of semaphores then in use. The Railway Company had actually ordered the telegraph to be removed as an encumbrance, when it happened that one Tawell committed a murder near Slough, and while travelling up to London a message was flashed along the wire to take note of a man in Quaker's dress. The man was accordingly watched until a warrant could be obtained; he was then arrested, and afterwards tried and hung. This practical illustration of the value of the electric telegraph made its fortune, and it spread rapidly. Hatcher had the honour of explaining the mechanism and mode of action to Her Majesty, the Prince Consort, and some of the royal children. It is, however, to be lamented that in the disputes that arose between Cooke and Wheatstone Hatcher sided with the former, which gave great offence to the scientific party, and Hatcher tendered his resignation, which was accepted.

About this time Price's Candle Company was founded, and one of the directors being an old King's College man, Hatcher was appointed chemist to one of the works in the Old Kent-road; afterwards to the more extensive works at Bromborough Pool, near Birkendead, and lastly to the company's most extensive works at Battersea, where he died on Saturday evening, the 2nd ultimo, after suffering during some months from a most painful internal disorder. The funeral took place on the following Wednesday afternoon at Battersea Cemetery.

It is impossible in this brief notice to convey an adequate idea of the beauty of Mr. Hatcher's character, or of his great and varied abilities. He practised the truth, courage, and courtesy of a perfect gentleman. He realised the definition of true and undefiled religion. He was well grounded in various departments of science. He was a good artist (a pupil of the late Mr. Read, of Salisbury), a good musician, and keenly alive to the beauties of literature. But still the most prominent feature of his character was devotion to the welfare of others. Goodness and usefulness seemed to radiate from him as from a centre; and all who came or were attracted within the circle of his influence seemed to breathe a purer atmosphere. He founded a number of useful classes for the men and children of the factory; mutual improvement classes, lectures (Hatcher was himself a charming lecturer as well as a clear and elegant writer), Sunday-school teaching, music classes, drum and fife band, volunteers, natural history, excursions, &c. He was himself a diligent collector, and his natural history specimens would be a prize for Salisbury, which might easily be secured. Although his duties confined him to a crowded neighbourhood, he had a keen eye for the beauties of nature, and an almost passionate longing for grand and lovely scenery. One of his recent holiday visits was to the Scilly Isles, which afterwards formed the subject of one of his delightful lectures, illustrated, according to his habit, by photographic slides and the oxy-hydrogen lamp. He was also an admirable microscopic observer.

What more can the writer of this imperfect sketch say, except that after a friendship of forty years he would place him on the same level with two other most perfect characters that it has been his good fortune to know, namely, Michael Faraday and William Allen Miller. Hatcher's singular modesty restrained him from seeking admission into the scientific societies of London, or from publishing the many scientific discoveries he had made, and of which, in some cases, others obtained the credit. He read a paper a few years ago before the Chemical Society on the Stearines; but this was rather in the interests of the company than in those of his own fame. He led a single life, and desired that no stone or monument should be placed over his grave.

C. TOMLINSON, F.R.S

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THE ELECTRICIAN.

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MILITARY TELEGRAPHY.

Success in war depends on many factors, and not the least important among these is time. Time to convey orders, time to receive information, time to move troops, stores, &c., is so essential that the ability to obtain a few hours, in some cases a few minutes more or less, makes or mars a well planned scheme. No civilised nation exists but has provided means for rapid communication for commercial and home purposes, and has generally provided a more or less complete telegraphic system for troops in the field. Generally the telegraph is used merely as the connecting link between the base and the front, but its use is advocated on the field of battle itself. In bygone days—far, however, in the misty ages of romance—orders must all have been given on the battle field by word of mouth, this verbal usage then gave place to prearranged signals by means of trumpets or horns, a method of conveying orders over a limited area in extensive use at the present day. Communications over longer distances were made by means of flags, and so on, but all these methods seem destined to give place to electrical apparatus. One obvious objection to "bugle" or similar sounds on the battle field is that enemies as well as friends can interpret the sounds. This fatal objection must again be made to flags, and hence it seems an absolute necessity that the actual order should be given verbally, inasmuch as there is less danger by the use of such means in the secret being known to the enemy. As we have previously said, much depends on the time taken to deliver an order. An aide-de-camp may gallop from part of the field to the other, but it takes time—and time, too, at a period when the manœuvres wanted must be executed to the minute to be effective. Without dwelling any longer on the factor of time in the operation of war, we may direct attention to an elaborate paper read before the Royal United Service Institution by Major Webber during its late session. The title of this paper was "Orders in the Field and the Means of Communicating them," and, since the reading of the paper, Major Webber has had some experience to test the theoretical assumption put forward by him. It is hardly fair to speak of them as theoretical assumptions, because the conclusions were based upon actual experience. The electric telegraph was used in the field so long ago as 1853 at the siege of Olmutz. In the war of secession the Americans used upwards of 8,000 miles of telegraph line for military purposes. During Sherman's celebrated march, his head-quarters were generally in telegraphic communication with his base daily, within two hours of halting. The lines were first worked under fire on the field of Fredericksburg. "Constant and reliable use was made of the line during the battle." In the Crimea, in Ashantee, in the Zulu campaign, in Afghanistan, &c., the telegraph has been more or less used by English troops. Its most extensive use, however, seems to have been by Lopez in the "Paraguayan war." "In December, 1868, the Allies were being held by the Paraguayans before the lines of Angusturo and Loma. The right flank rested on the River Paraguay. Within the lines every point was joined by the telegraph with head-quarters, and the Paraguayan leader had a telegraph line also to the capital, Assompcion, and was thus enabled to hold a very extended position with a comparatively small army. The river at Palmo, where the left of the Allies rested, was a kilomètre wide, and the other shore was an impenetrable, wild, swampy country, called the Gran Chaco. The Allies, however, determined to throw a division across, make a road through the Gran Chaco, recross the river about 20 kilomètres above, at Itororo, and take the Paraguayans in rear at Viletta. This they succeeded in doing, and telegraphic communication was at the same time kept up with the head-quarters by a line ome 23 kilomètres in len gth. Hardly had the division reached Itororo, when the river rose, and all communication, except by telegraph, was cut off. The Paraguayans made repeated attacks on the line, and the Allies used every effort to maintain it, and many lives were lost in the struggle. It remained in use until the 21st December, when the Paraguayans were driven by the flank movement from all their positions. Without the telegraph this would have been next to impossible. . . . . At the battle of the Lines of Curupaiti on the 22nd September, 1866, the Paraguayan right resting on the river of the same name, the right and front were attacked by the

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Allies with eight ironclads and a force of 14,000 infantry. The Paraguayans had 49 guns and 5,000 men engaged behind their defences, and the reserve was about three kilomètres in rear at Lopez's head-quarters. General Diez commanded in front, and the loss in killed and wounded on both sides was over 9,000 men. One of the telegraph lines of the defence was carried a distance of four-and-a-half kilomètres from General Lopez's tent to General Diez at Passo Poqu, where there was a small earthwork behind which two operators worked a Morse inking telegraph, the wire being carried on palm-tree poles about 18 feet above the ground. During the whole action the telegraph station was in the line of heaviest fire, one large shell burst in the parapet, half filled the work with earth, and upset the communication during 12 minutes, but the line was never broken, and only two insulators destroyed. While not receiving orders, General Diez was continually telling Lopez how the battle proceeded. Lopez sat in his tent listening to the operator interpreting the signals, and looking at the map. This was his invariable custom, and he was a man quite ready to have made his Telegraph Director responsible with his life for the lines being duly put up and maintained. He himself believed that this means enabled him to carry on a bloody and determined war for five years, until he had exhausted every man and every material resource in Paraguay."

Another and very successful example can be taken from the recent Turko-Russian war in Asia Minor :—" In October, 1877, the Russians decided to cut off Muktar's communications with Kars and Erzeroum, and thus, by threatening his front and rear, make his strong position untenable. General Lazareff was detached with this object, in command of 27 battalions, 40 guns, and 6 regiments of cavalry. Marching south, down the Arpa Tschar (River) he passed Muktar's right flank at Kotchiran, he turned to his right to Dighur, and thence making north-west, he made the Oghur Hill and the village of Vezinkoi, fortified by the Turks, his objective; and thus planted himself right on Muktar's communications. Now, what was it that made possible and rational this division of an Army in the presence of a powerful enemy? What prevented Muktar now crushing each portion in succession, as was evidently his intention, by his having immediately sent a large force, under Reshid Pasha, to attack Lazareff? It was that along the 40 miles' march of that General a reliable telegraph line had been constructed which only once, and that but for two hours, was interrupted, and which, at 3 a.m. on the 14th of October, conveyed a message from Lazareff to the Grand Duke that Muktar was in front of him with a stronger force than his own. Thus, as it were, placed face to face with his subordinate, 40 miles off, the Commander-in-Chief held his enemy in his hand. One small telegraph wire was round the neck of the Turk, and he could not escape. The combination was perfect, and the orders to attack on each side were simultaneously carried out, with the result of the fall of Northern Armenia." Here, then, are examples occurring in actual operation, upon which the value of field telegraphy can be discussed.

Such important work requires an apparatus simple to construct, not liable to get out of order, accurate and efficient. To obtain a perfect apparatus of this kind is no easy matter. The telegraph has not been sufficiently tested to determine whether it fulfils all the demands. Major Webber pointed out the vast labour bestowed on an army, and the important national results arising from such a machine being put into motion. Hence the necessity of an order being exact and its meaning unmistakable. "The machinist knows that, once steam is turned on, every part of the beautiful mechanism he has executed will move in perfect unison, each following and fitting to each without a will of its own. The sower knows that his seed will grow into stalk and branches, leaves and fruit. But, the order which sets the vast machine of an army in motion has to contend with individual wills, misunderstandings, and idiosyncrasies, throughout its execution, and, however prepared the great machine may be, there are thousands of unforseen contingencies that may arise in its mere interpretation and development which may mar the full result that the order is intended to produce." This message, fraught with national importance, has to be conveyed as quickly and as secretly as possible to the point required. If, after further trial, electricity is found equal to these requirements, a great stride will have been made in warfare, and we shall have drawn nearer the end, for, when the art of killing becomes a certainty, then men will refuse to be killed. Given arms of still greater precision than are at present used, and take away one by one the chances of mistakes arising on the battle-field, only one result can ensue, and that is peace.

The difficulties to be overcome before perfection is reached may be understood from the remarks on Field Telegraphs, in the paper. " A well-considered system on Field Telegraphs should be perfect in the simplicity of its appliances, and in the efficiency of its *employés*, because it is called on to do what is always the most difficult operation in Telegraphy, namely, to establish a communication rapidly with materials of not a permanent character, and maintain it with certainty. There is a feature in Telegraphic Engineering which makes it differ from all other branches of science in which mind utilises matter; and this is due to the subtle nature of the force employed, and to the difficulty which any but very practically-trained minds find in quickly grasping every fact connected with it. For instance, the most perfectly devised Field Telegraph may be established and at work, and suddenly fail from one of many possible causes, and remain so for hours before it is restored. This is no reproach to the *personnel*, for, even in permanent Telegraphs, and with every possible precaution, such a thing occasionally happens, when a mind, which is not daily in the habit of meeting quickly these small difficulties, has to deal with such a case. In our Postal Telegraphs, everyone who has to do with the daily necessity which arises out of arranging for and working special communications established for Press and other purposes, is specially selected as the best of his class, to attend on, and supervise the operations; even then failures occur. How much more, when the effect of failure might be so much more disastrous, is it necessary to provide the very best devised means and the highest trained staff for the emergencies of war. It has been sometimes said that Military Telegraphs are so simple that the efficiency of persons employed in State Telegraphs would be thrown away in attendance on them, because, to the outside observer, the latter *looks* so complicated with its number of wires and its intricate apparatus, while a mere line and an instrument at each end *looks* so simple. The reverse is the case. In State Telegraphs, with hundreds of wires and instruments everywhere, complete failure of communication need hardly ever occur, whereas, when all depends on one or two lines and few appliances, it requires very quick and ready resources indeed to foresee or prevent interruptions. It is not the complication of many lines and instruments which it is difficult to grasp. It is the readiness of resources, the accuracy of investigation, and the prompt decision to act with certainty of success, which makes a practically-trained Telegraph Engineer doubly useful in Military operations. Besides, the Military Telegraph Engineer may be called on at a moment's notice

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to adopt and use the existing State Telegraphs in his own or an enemy's country, and to do this a very thorough and varied experience is necessary."

We quite agree that the tapping of a telegraph line by means say of a Morse instrument, and the *deceiving* of the original senders is an exceedingly difficult task, but the tapping of a wire by means of a telephone to learn the messages passing to and fro is very easy. Indeed, the introduction of the telephone has made it all but impossible to keep secret the work of the wire. In the case of orders in the field there is, of course, little or no chance of an enemy being able to tamper with the wire, or even if a spy could obtain access to any portion, there would be no time to use the information obtained, except at a great risk. Suppose that the tapping of the line is not so difficult a matter, it is easy to obviate all danger, even with the ordinary instruments, by using cypher messages. We have, however, in such systems as that of D'Arlincourt, and preferably that of Cowper, an easy means of overcoming the difficulty. No telephonist could interpret a message sent by Cowper's writing instrument, and thus we venture to say that almost absolute secrecy can be promised to messages so far as tapping the wires is concerned.

Time will give more facts as regards this particular use of electricity, and till then opinions on this point may be withheld.

THE USE OF THE ELECTRIC LIGHT AT PLACES OF HOLIDAY RESORT.

Considered from a rigidly economical and utilitarian point of view, electric lighting, in its present stage, cannot generally be said to offer decided and unquestionable advantages over gas lighting. But its employment as a *lumière de luxe*, where brilliancy and effect will meet with ready and extended appreciation, is now not only practicable but in many cases commercially expedient. In such cases its neglect may often be traced to a want of enterprise and initiative, the negative result of which is in every sense disadvantageous. We are glad to observe that the local authorities of the most popular of the watering-places in the North, namely, Blackpool, cannot be charged with this deficiency, and that the attractiveness of the locality has been greatly enhanced by electric illumination. The experiment, which is the more creditable from the fact of its having been carried out in spite of a first failure, due to the high tides which swept the beach and promenade and destroyed the insulation of the wires by filling with salt water the pipes in which they were laid, is an undoubted and very striking success. Blackpool, which at this advanced season of the year is usually nearly empty, is now filled to repletion with from 70,000 to 100,000 visitors. A correspondent complains that not a room, or even a sofa, is to be had in any of the hotels, from the Imperial downwards, unless it is ordered a fortnight beforehand; whilst the lodging houses are full to overflowing, and excursion trains from all parts of the country bring into the town thousands of persons who return at night, after the *fête*, to their respective homes.

It appears that in the Improvement Bill obtained during the past Session of Parliament power was granted to the Corporation to devote a sum of £5,000 to experimenting on electric lighting; and, notwithstanding the advanced period of the season, a committee was appointed to make the necessary arrangements for carrying out an experiment on an extended scale. The dynamo-electric machine selected was that of Dr. Siemens, who has given some personal attention to the work, which was mainly in charge of his representative, Mr. Andrews, and Mr. Chew, the gas-engineer to the Corporation. The dynamo-electric machines are eight in number, and produce as many lights, each estimated to have an illuminating power equal to 6,000 sperm candles, or 48,000 candles in the whole. Six of the electric lamps are suspended from poles at a height of 60 feet from the ground, and are so arranged as to occupy three sides of a quadrangle or square, formed by the promenade and the two piers, the total length of the three sides being about 1,800 yards, and the lamps averaging 320 yards distance apart. The remaining two lamps are fixed on the roof of the Prince of Wales's Theatre, which fronts the promenade, and is situated midway between the piers. Moveable parabolic reflectors are placed behind these two lamps, by means of which a beam of light can be projected in any direction. From the dynamo-electric machines in the town's yard to the farthest light on the south pier, the wire is 1,300 yards in length, and the distance to the nearest light is 250 yards. A separate leading wire is carried to each lamp, and one common return wire serves for the whole. All these wires are of copper, varying in the number of strands in each, and are insulated with gutta percha covered by india rubber.

We think we may congratulate the Electric Lighting Committee of the Town Council of Blackpool upon the ultimate results of their endeavours in a direction where, we doubt not, their initiative will be most valuable, and will find many followers amongst other local authorities in places of holiday resort.

A NEW TEXT BOOK ON ELECTRICITY, MAGNETISM, &c.

For a long time students of electricity have been desirous of seeing some capable author writing an original treatise on electrical subjects, adapted to the wants of the non-mathematical reader, or rather to those who, having a fair knowledge of algebra, have little or no knowledge of the calculus. The want is about to be supplied in a work by Mr. J. E. H. Gordon, B.A., to be published by Messrs. Sampson Low and Co. towards the end of the year. We have, by the kindness of the author, been able to see a large number of the illustrations and advanced proofs of portions of the work, and from these we are entitled to say that the work will be exceedingly well illustrated, and the treatment of the subject differs considerably from that followed by Ganot, Deschanel, and similar writers. The author has, in fact, followed his own plan, and ignored the objectionable methods of many previous writers, who were content to follow closely in the footsteps of previous authors. We may say that the most recent investigations are incorporated in the text, and believe that the work will meet, as it merits, a hearty welcome from all electrical students. We hope in our next issue to sketch the plan followed in this work.

CORRESPONDENCE.

SPLIT BATTERY DUPLEX.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: In reply to Mr. Johnston's letter in your last week's issue:—

I was not aware that any part of the arrangement of apparatus which I saw at work in the Madras Telegraph Office was due to the late Mr. Brough, and Mr. Winter, in a letter which I received before the appearance of Mr. Brough's letter in your journal, informed me that he had shown the improved double-tongued relay to that gentleman in confidence.

But the sad death of that talented officer makes all further discussion out of the question.—Yours, &c.,

ALEX. MUIRHEAD.

29, Regency-street, Westminster, S.W., Sept. 30.

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NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONTINUED FROM P. 188.)

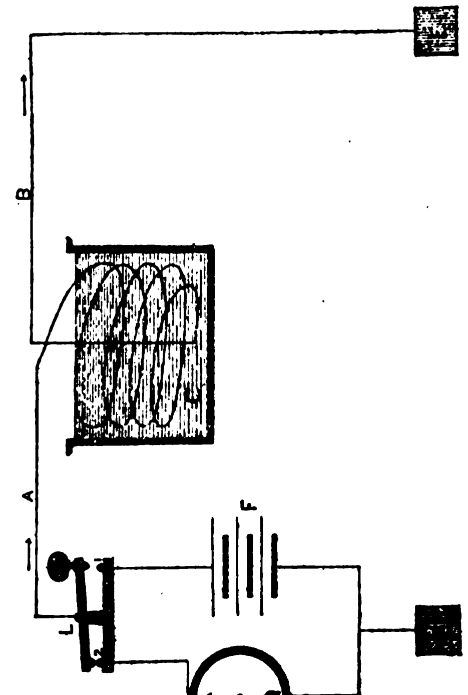
II.

THE "COIL CURRENT" OR "FALSE DISCHARGE."

On the 14th February, 1862, Mr. Willoughly Smith published in *The Electrician* (old series) the results of his experiments in relation to this phenomenon, which had two and a half years previously been noticed for the first time, in the case of submarine cables, by Mr. F. C. Webb. Disconnected from all the effects due to electrostatic charge, the phenomenon in question, under the name of *extra current*, had been for a long time quite familiar to all electricians accustomed to the use of powerful electro-magnets or current-induction apparatus; but in its new aspect it was not at first recognised as identical with the current which produces the spark observed when a circuit containing an electro-magnet, or otherwise subject to "electro-magnetic retardation," is broken. In fact, so little was the coil current understood that the effect due to the virtual withdrawal of a magnet from the coil was ascribed by no less an authority than Prof. Wheatstone to the "polarisation" of earth plates; the circumstance that any current due to the latter cause must necessarily be in a direction opposite to that of the coil current being unaccountably overlooked.

Referring to the diagram, in which C is a short length of gutta percha covered wire coiled in a tank, F a battery, G a galvanometer, L a double-contact key, and E E two earth-plates, it was shown by Mr. Willoughby Smith that, when the key is released after being depressed, the (false) discharge is much in excess of the charge, and in the direction opposite to that of the true discharge obtainable when the distant end of the "cable" is insulated. He also pointed out that the difference is much more marked when the wire is wound upon an iron core or reel.

3



For the benefit of our electrical students, it may be useful to analyse the various effects which take place in the experiment here indicated. When the key is depressed, two effects occur simultaneously:—(*a*) the communication of an electrostatic charge to the insulated conductor, and (*b*) the virtual insertion of an electro-magnet within the coil C. The latter effect is of course greatly intensified when the coil is wound upon a soft iron core, and thus constitutes an electro-magnet; but a simple helix of wire, when traversed by a current, possesses in smaller degree the properties of a magnet. These two effects tend to neutralise each other; for the current produced by magnetising the coil is necessarily (by the principle of the conservation of energy) in a direction opposite to that of the magnetising current and also to that of the charging current. The latter, however, preponderates; and the rush of electricity producing the charge may be distinctly observable when a galvanometer is inserted at the point marked A. But, by the conversion of electrical energy into magnetic energy, the normal current which, in accordance with Ohm's law, will ultimately traverse the circuit will be *retarded* for a space of time which, under certain conditions, may be rendered very appreciable. During this period, although the consumption of zinc which results in the production of electrical energy is undoubtedly taking place in the battery, no corresponding effect is produced upon a galvanometer at A. By the effect of the magneto-electric *induced current on making contact* the primary current is not only apparently absorbed but loses its effect upon the galvanometer, and, in fact, *disappears* from the circuit during a period of time dependent upon the "electro-magnetic inertia" of the coil. It is important to clearly understand that this primary current is not simply arrested by an opposing current, so as to stop the action of the battery producing it; but that we have here a case in which electricity apparently disappears, and in which electrical energy (the product of electrical quantity into electrical tension or potential) is converted *pro tem.* into electro-magnetic energy. At the end of the very brief period referred to, a third effect (c) takes place, viz.:—the passage of the normal battery current, which will deflect to the same degree a galvanometer at A or at B, and will "polarise" the earth plates EE, in the same manner as the plates in the secondary battery shown in Fig. 1 (p. 188) become polarised, *i. e.*, so that a current of polarisation will tend to pass in the direction opposite to that of the battery current. Thus, the uppermost pole of the battery shown at F in Fig. 3 being positive, the right hand earth plate, constituting the anode, will tend to become oxidised, and will form the negative element or positive pole of an earth couple; whilst the left-hand plate, constituting the cathode, will become coated with the electro-positive hydrogen, and will form the positive element or negative pole of the earth couple.

Now, when the key is released, three effects will occur simultaneously, or nearly so. A current of discharge (*d*) will flow in the direction opposite to that indicated by the arrows; and this will become augmented by the current of polarisation (*e*) from the earth plates. The third effect (*f*) is that due to the virtual withdrawal of a magnet from the coil C, or to the reconversion of its magnetic energy into electrical energy. It is this effect which constitutes the "coil current" or "false discharge." The direction of this induced current is of course opposite to that of the current produced by the virtual insertion of a magnet within the coil, *i. e.* it will be that indicated by the arrows, or that in which the primary current traversed the circuit. The energy of of the coil current will be the exact equivalent of the electrical energy which disappeared in the first instance from the primary current, and which became stored up as magnetic work or potential energy within the coil. Under ordinary circumstances, when a circuit containing an electro-magnet is broken, this energy, which may have been stored up during a comparatively considerable period of time, is instantaneously expended in the production of the *extra current* to which is due the spark between the separated points of contact. This extra current may therefore be of very considerable power in comparison with the primary current which is interrupted; thus it is very frequently utilised in magneto-electric apparatus intended for the production of "shocks."

The following extracts from the letter of Mr. F. C. Webb, published in *The Engineer* of August 26, 1859, in which that electrician first drew attention to the phenomenon of "false discharge," are of historical interest in connection with this subject:—

ELECTRIC INDUCTION IN COILED SUBMARINE CABLES.

"It has for some time been noticed by a few practical engineers that the retardation of signals in long lengths of submarine cables was much greater when the cable was in a coiled state than when stretched out straight; and, indeed, this to such an extent that it has frequently been found almost impossible to transmit messages until a great portion of the cable was payed-out. This effect is evidently due to the induction which takes place between the proximate convolutions of the cable, the whole coil forming as it were a large induction coil. . . . . . Some important features in the comportment of the current under these circumstances have from time to time been noticed by me, and have lately been brought before me in a more prominent degree; and as the whole phenomena are of the utmost importance to submarine telegraphy I think it right to make my observations public, as I am not aware that they have ever been noticed by any one else."

Mr. Webb then describes the results usually obtained on charging and discharging a submarine cable when laid, and proceeds to compare them with those obtained on connecting up a similar cable, AB, in a similar manner, when coiled:—

"If now the cable be in a coiled state, some very curious differences will be observable in the action. If the end B is insulated the charge and discharge will take place in their usual manner, except perhaps rather more sluggishly. When, however, the end B is to earth, a very marked and singular difference is observable.

"On making contact both needles will be deflected in a much more sluggish manner, and the time taken before both will arrive at the same deflection (*i.e.* the retardation) will be very greatly increased. It is however on making contact with earth between the battery and the glvanometer at A end of the cable that the greatest and most singular difference

occurs. It will then be seen that the needle of the galvanometer at A, instead of being reversed will continue deflected in the original direction, and both needles will very gradually resume the perpendicular. Here is a most marked and curious difference between the effects produced on a coiled and on a straight cable. The return current appears obliterated or rather it is overpowered by the effects of the induction which takes place from coil to coil. The deflection thus produced is much greater than that produced by the return current. I have had, perhaps, peculiar facilities for observing this striking phenomenon. Whilst picking up cables at sea, I frequently test the length I am operating upon for the return current, and, as the cable becomes coiled into the ship the direction of the needles becomes reversed when testing for return current. It is also my practice to cut the cable at certain distances as it is picked up and then test such sections separately. On these occasions sections which, when one end is insulated, will give a charge and discharge of 5°, will, when that end is brought to earth, give a current at the battery end, after contact, of 90°, but in the reverse direction to which the charge or discharge would be if the cable were laid out straight. That this effect is produced by the inductive action between the convolutions of the coil, which actually overpowers the return current, is apparently proved by the following experiment. Having at hand one of the large induction coils of the Atlantic Telegraph Company I insulated one end of the secondary coils and then attempted to procure a static charge in the wire, but though I connected the primary wire and iron core to earth (which were the nearest conductors to which it could induce) I failed to produce the slightest static charge. I then put the end of the secondary to earth, and all the curious retarding effects were reproduced in a remarkable degree; the needles of the galvanometers at each end deflected only slowly on making contact with the battery, and when contact was broken they resumed the perpendicular still more slowly. Here the sluggish effect was produced without any of the conditions for a static charge and with the most favourable conditions for induction from coil to coil; the effect produced being similar to that produced in a coiled submarine cable.

"In a submarine cable the conditions for a static charge exist, since it can be observed by charging and discharging when the end is insulated. It can only be inferred from this, therefore, that the effects of the sluggishness or retardation are increased by the coiled state at the far end, whilst the return current is actually overpowered at the near end.

"The strength of the currents thus produced, and the great time they continue to act after contact is broken with the battery are most extraordinary. This may be imagined when I say that a length of ten miles of cable so coiled, which only gave a charge and discharge of 5° with one end insulated (and on which the return current if the length were stretched out straight would have been scarcely measurable) gave a current after contact was broken with the battery of 90°, whilst the time occupied before the needle resumed the perpendicular was several seconds. The effect appears to indicate a current flowing into the cable at the near end and out at the far end and in the same direction as the primary current instead of out at both ends, as in the case of a cable stretched out straight.

"It seems strange to me that this curious effect has not been more noticed; yet I firmly believe that, although the increased difficulty of working through a coiled cable has been observed by a few electricians, the direction of the current at the near end has never before been alluded to."

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The following is a more complete abstract of Mr. T. A. Edison's Paper read before this Association than we were able to give in our last impression. He said :—

"In the course of my experiments on electric lighting, I have developed some striking phenomena arising from the heating of metals by flames and by the electric current, especially wires of platinum and platinum alloyed with iridium. These experiments are still in progress. The first fact observed was that platinum lost weight when heated in a flame of hydrogen; that the metal coloured the flame green; and that these two results continued until the whole of the platinum in contact with the flame had disappeared. A platinum wire four-thousandths of an inch in diameter, and weighing 306 milligrammes, was bunched together and suspended in a hydrogen flame. It lost weight at the rate of a fraction less than 1 milligramme per hour as long as it was suspended in the flame. When a platinum wire is stretched between two clamping-posts and arranged so as to pass through a hydrogen flame, it is coloured a light green, but when the temperature of the wire is raised above that of the flame by passing a current through it, the flame is coloured a deep green.

"A platinum wire twenty-thousandths of an inch in diameter was wound in the form of a spiral one-eight of an inch in diameter and one-half an inch in length. The two ends of the spiral were secured to the clamping-posts, and the whole apparatus was covered with a glass shade 2½ inches in diameter and 3 inches high. Upon bringing the spiral to incandescence for twenty minutes, that part of the globe in line with the sides of the spiral became slightly darkened; in five hours the deposit became so thick that the incandescent spiral could not be seen through the deposit. This film, which was most perfect, consisted of platinum, and I have no doubt that large plates of glass might be coated economically by placing them on each side of a large sheet of platinum, kept incandescent by the electric current. This loss in weight, together with the deposit on the glass, presented a very serious obstacle to the use of metallic wires for giving light by incandescence, but this was easily surmounted after the cause was ascertained. I coated the wire forming the spiral with the oxide of magnesium by dusting upon it finely-powdered acetate of magnesium. While incandescent, the salt was decomposed by the heat, and there remained a strongly-adherent coating of the oxide. This spiral so coated was covered with a glass shade, and brought to incandescence for several minutes; but, instead of a deposit of platinum upon the glass, there was a deposit of the oxide of magnesia. From this and other experiments I became convinced that this effect was due to the washing action of the air upon the spiral; thus the loss of weight in, and the coloration of, the hydrogen flame was also due to the wearing away of the surface of the platina by the attrition produced by the impact of the stream of gases upon the highly incandescent surface, and not to volatilisation, as commonly understood; and I venture to say, although I have not tried the experiment, that metallic sodium cannot be volatilised in high vacua by the heat derived from incandescent platinum; any effect that may be produced will be due to the washing action of the residual air.

"I will now describe other and far more important phenomena observed in my experiments. If a short length of platinum wire, one-thousandth of an inch in diameter, be held in the flame of a Bunsen burner, at some part it will fuse, and a piece of the wire will be bent at an angle by the action of the globule of melted platinum; in some cases there are several globules formed simultaneously, and the wire assumes a zigzag shape. With a wire four-thousandths of an inch in diameter this effect does not take place, as the temperature cannot be raised to equal that of the smaller wire, owing to the increased radiating surface and mass. After heating, if the wire be examined under a microscope, that part of the surface which has been incandescent will be found covered with innumerable cracks. If the wire be placed between clamping-posts and heated to incandescence for twenty minutes by the passage of an electric current, the cracks will be so enlarged as to be seen with the naked eye. The wire, under the microscope, presents a shrunken appearance, and is full of deep cracks. If the current is continued for several hours, these effects will so increase that the wire will fall to pieces. This disintegration has been noticed in platina long subjected to the action of a flame by Professor John M. Draper. The failure of the process of lighting invented by the French chemist Tessie Du Motay, who raised sheets of platinum to incandescence by introducing them into a hydrogen flame, was due to the rapid disintegration of the metal. I have ascertained the cause of this phenomenon, and have succeeded in eliminating that which produces it, and in doing so have produced a metal in a state hitherto unknown, and which is absolutely stable at a temperature where nearly all substances melt or are consumed—a metal which, although originally soft and pliable, becomes as homogeneous as glass and as rigid as steel. When wound in the form of a spiral it is as springy and elastic when at the most dazzling incandescence as when cold, and cannot be annealed by any process now commonly known; for the cause of this shrinking and cracking of the wire is due entirely to the expansion of the air in the mechanical and physical pores of the platinum, and the contraction upon the escape of the air. Platinum, as sold in commerce, may be compared to sandstone, in which the whole is made of a great number of particles, with many air-spaces. The sandstone, upon melting, becomes homogeneous, and no air-spaces exist. With platinum or any metal, the air-spaces may be eliminated and the metal made homogeneous by a very simple process. My experiments with many metals treated by this process have proved to my satisfaction, and I have no hesitation in stating that, what is known as annealing of metals to make them soft and pliable is nothing more than the cracking of the metal. In every case where a hard-drawn wire had been annealed, a powerful microscope revealed myriads of cracks in the metal. Since the experiments of which I have just spoken, I have, by the aid of Sprengel mercury pumps, produced higher exhaustion, and have, by consuming five hours in excluding the air from the wire and intermitting the current a great number of times, succeeded in obtaining a light of eight standard candles from a spiral of wire with a total radiating surface of $\frac{1}{30}$ second of an inch, or a surface about equal to a grain of buckwheat. With spirals of this small size, which have not passed through the process, the average amount of light given out before melting is less than one standard candle. Thus I am enabled, by the increased capacity of platinum, to withstand high temperatures, to employ small radiating surfaces, and thus reduce the energy required for candle light. I can now obtain eight separate jets, each giving out an absolutely steady light, and each equal to 16 standard candles, or a total of 128 candles, by the expenditure of 30,000 foot-pounds of energy, or less than 1 horse-power. As a matter of curiosity I have made spirals of other metals, and excluded the air from them in the manner stated. Common iron wire may be made to give a light

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greater than platinum not heated. The iron becomes as hard as steel, and just as elastic. Nickel is far more refractory than iron. Steel wire used in pianos becomes decarbonised, but remains hard, and assumes the colour of silver. Aluminium melts only at a white heat.

"In conclusion, it may be interesting to state that the melting point of many oxides is dependent upon the manner of applying the heat. For instance, pure oxide of zerconium does not fuse in the flame of the oxyhydrogen blow-pipe, while it melts like wax and conducts electricity when on an incandescent platinum spiral which is at a far lower temperature. On the other hand, oxide of aluminium easily melts in the oxyhydrogen flame, while it only vitrifies on the platinum spiral."

CONTACT THEORY OF VOLTAIC ACTION.

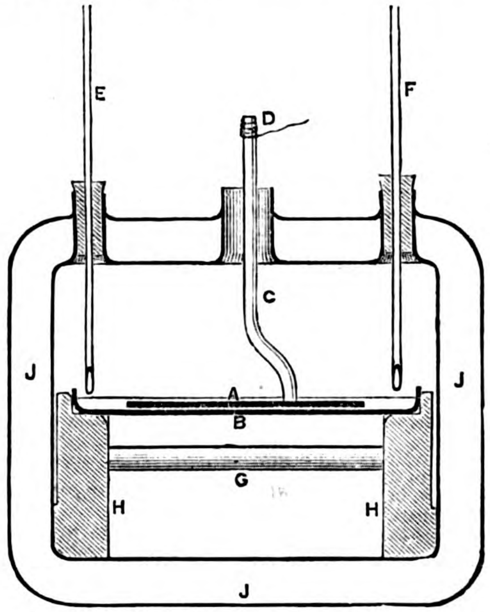
Parts I and II.

By W. E. Ayrton and John Perry, Professors in the Imperial College of Engineering, Tokio, Japan.

Part II. (continued from page 226).

On Electrolytes of Great Resistance.

To measure the electromotive force of the voltaic cell formed by plates of zinc and copper separated by paraffin wax and other electrolytes of great resistance, and to determine the change of conductivity of such electrolytes with temperature, we used the apparatus shown in the figure.



J is an oil bath, which may be clamped firmly to an iron stand resting on the table of such a height that D is on a level with the electrode of the electrometer. The bath was heated by means of spirit lamps. No artificial means of cooling the bath were employed. B is a shallow dish of copper, quite plane on the bottom inner surface, and containing the electrolyte. A is a circular plate of zinc, or of copper, 12·8 centims. diameter, resting in the experiment in paraffin wax on three small pieces of glass, 0·191 centim. thick; the metal was very clean, and was quite surrounded by paraffin wax poured in in a melted state. The strip C is in one piece with the plate A, both being cut from the same piece of metal; C is bent upwards, and passes through an orifice in the bath. The wire from D to the insulated electrode of the electrometer is protected by a wide tube of metal; this tube, the outside of the electrometer, and the uninsulated electrode being connected with B. A double door (not shown in the figure) gives access to the inside of the bath. H G H is a wooden support which may be withdrawn from the bath. E and F are thermometers, of which the bulbs are near the surface of the paraffin. The difficulty of determining exactly the temperature of the paraffin wax arose from its non-conductivity; and the use of a third thermometer, passing through a tubulure horizontally underneath B, was found to add nothing to the accuracy of the temperature readings.

To obtain continuous time readings of the electrometer, we let the image of the cross fibres of our lamp slit formed by the mirror fall on a horizontal wooden roller covered with paper. This roller was 100 centims. long, and 13 centims. in diameter. A clock causes the roller to make a revolution in two minutes. We are able suddenly to change the rate of this roller to one revolution in 7·2 minutes, and we can also slightly vary the rate by altering the length of the pendulum. The image of the cross fibres is easily followed in its motion on the paper by a pencil. When the paper is cut off at any place parallel to the roller-axis it exhibits the time observations in a compact form well adapted for calculation. The clock being stopped, and a scale attached to the roller, readings may be made in the ordinary way. Such a roller and clock cost very little, and form a valuable addition to every reflecting galvanometer or electrometer.

Paraffin Wax.

The plate A being zinc and connected with the insulated electrometer electrode, and the paraffin being solid between the two plates, we first short-circuited the arrangement to get zero, then insulated and allowed the electromotive force of the paraffin cell to charge plate A, and the electrometer quadrants in connection with it.

A detailed account of our experiments on conductivity is given further on. It is sufficient here to state that at low temperatures the conductivity of paraffin wax is exceedingly small, the conductivity increases to the melting point, the increase being extremely rapid during melting, and there seems to be a regular increase during the melted state. Hence, in the experiments with the zinc plate at low temperatures the resistance is so great that, although there is a slight charging of the quadrants due to electromotive force, this is somewhat disguised by defects of the electrometer. In fact, at low temperatures, it is impossible to measure the electromotive force of this simple cell, although the existence of an electromotive force is quite evident; but when the conductivity becomes sufficiently great—and this occurs long before there is any appearance of melting on the upper surface of the paraffin—the charge reaches a maximum with sufficient rapidity for its accurate measurement. At a few degrees above the melting point, the maximum charge established itself at once, and however often the plates were short-circuited for the purpose of taking the zero, the maximum charge was found to be approximately the same, and to correspond with an electromotive force 0·73 volt when least, and 0·75 volt when greatest: it was also not much affected by change of temperature. To make these measurements, we used as a standard a Latimer Clark's constant cell.*

When the plates are charged to their maximum difference of potentials there is electric equilibrium, and no further current tends to pass through the arrangement, the electromotive force being balanced. If, then, E_0 represents this maximum charge, and if E_1 is the charge at a time (t_1), and E_2 the charge at the time t_2, then

$$\frac{1}{t_2 - t_1} \log \frac{E_0 - E_1}{E_0 - E_2},$$

multiplied by a constant depending on the electric capacity of the arrangement, represents the conductivity. As the measurement of any particular temperature is rather coarse, we cannot readily compare this conductivity with the conductivity for that temperature which we have otherwise determined, but we infer from the curve that the above formula gives a result twice or three times as great as the true conductivity: this, however, might have been expected from our knowledge of the phenomena of absorption in dielectrics.

Sir W. Thomson, in the "Proceedings of the Royal Society" for June 10th, 1875, describes an experiment in which plates of zinc and copper, in contact with the two sides of a plate of glass, form a voltaic cell. When the glass was sufficiently heated to become conducting there was evident charging of the plates.† In the glass cell the maximum charge became less and less after every short-circuiting, whereas in the paraffin cell the maximum charge is constant. In the one case all the elements of the circuit were solid, the glass being very far indeed from its liquifying point, so that the amount of possible chemical action at the junctions was small, and after every successive short-circuiting, there was a less and less supply until the arrangement was approaching a state which had hitherto been supposed to be peculiar to a compound metallic circuit; whereas our paraffin possessed mobility, and the amount of possible chemical action at the surfaces of contact was practically infinite in comparison with the currents charging the plates.

It is stated above that when any two pure substances otherwise insulated are brought into contact with one another, the amount of chemical action must be practically *nil*, but, as perfectly pure substances do not exist, when two bodies are brought into contact

* In our last Paper we gave 0·75 volt as the correct measurement of the electromotive force of contact of zinc and copper.

† Our experiments of the increase of conductivity of glass with temperature are described in the "Proceedings of the Royal Society" for the same date.

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small complete circuits are formed by three or more different substances, and currents are produced until the possible chemical actions at the surfaces of contact are exhausted. Now, if one or more of these substances in such elementary circuits are non-conductors, this exhaustion can only proceed very slowly, and if the substances at the surfaces of contact have immobility, the total amount of possible chemical action will be necessarily small. Hence we see that the amount of chemical action between bodies depends upon their conductivity and mobility, as well as on the electromotive forces of contact, and as the chemical action equivalent to the energy of small charges of electricity is quite incapable of being detected by the ordinary methods of chemical analysis, and as the charges are easily measurable with an electrometer, we have, if our theory be correct, in electrical measurement a method of chemical analysis which is infinitely more sensitive than any purely chemical method. Thus it is evident that in our paraffin cell there is chemical action, but our colleague, Dr. Divers, has found no traces of zinc in English paraffin oil which came out to Japan in galvanised iron cases, nor in paraffin oil heated to a temperature of 60°C., in a zinc vessel for many hours. In fact in chemical analysis, something which is equivalent to current is measured by a method very much less sensitive than if the measurement were made by the best galvanometer, whereas a current which is not observable with the best galvanometer may be measured accurately with the electrometer.

It is plain that if we assume an electromotive force of contact between any two substances, there must be possible chemical action between these two substances, and this chemical action can of course only exist at the places of contact. It may proceed slowly through want of conductivity, and the amount possible in any given case may be very small because of want of mobility of either of the substances in contact, or of want of mobility of the compound formed by the action. Thus it is well known that the electromotive force of contact of glass and other substances is often very considerable, and that the chemical action between glass and most other substances is very small. This is due to want of conductivity of the glass, but when glass becomes heated, its conductivity much increases, and it then becomes capable of acting chemically on many substances. When in the melted state it is acted on chemically by the majority of substances. It is possible that this great increase of chemical activity accompanying a rise of temperature is much more due to increased conductivity than to change of electromotive force of contact. Lead glass, which insulates so badly, is comparatively easily acted on by chemicals. Chemical action is always slow, unless the substances are conductors, and we find that nearly all the substances which chemists find it unnecessary to dissolve before applying re-agents are conductors. In some cases previous solution may be also required for the mere purpose of producing mobility at the surfaces of contact. To expedite chemical action, solutions are stirred together. This increases the area of contact, and diminishes resistance, as well as rapidly bringing into contact fresh portions previously unacted on.

The alkaline earths in the solid state are very bad conductors, but when melted they are comparatively good conductors, and there is no doubt that we have here an explanation of the fact that the bottoms come out of platinum crucibles containing melted alkaline earths.

(TO BE CONTINUED.)

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

The twelfth ordinary general meeting of the shareholders in this Company was held on the 30th September, at the offices, 106, Cannon-street, under the presidency of Mr. Neil Bannatyne.

Mr. Charles Gerhardi, the manager, read the notice convening the meeting, and the report, which has appeared in *The Electrician*, was taken as read.

The Chairman said: If the shareholders looked at each account they would, no doubt, observe that the receipts for the half year were about £545 in excess of those for the corresponding half of 1878, while the working expenses showed an increase of about £220. The increase in the working expenses was exceptional. It was caused partly by exceptionally extensive repairs to the Company's underground lines in Spain and France during the six months, and to their contribution (£100) to the telegraph conference. That item would not occur again—at least for some years to come. These two items, indeed, accounted for the whole increase in their working expenses, so, but for these exceptional items, they would have earned £545 increase of revenue without any increase of working expenses. He trusted that they might for the future—or for some years at least—have no exceptional items, and that they would be able to keep their working expenses under £2,000 for the half year, which was always looked on as about the normal sum. The electrical condition of both cables, from reports received that day, continued as perfect as ever, and that had been the uniform report of the electrical engineer since their last meeting. Their cables had all along maintained the first-rate condition at which they had been for a long time past. As regarded the present half year, they would observe by the report what the directors recommended—that was, to place £500 to the credit of the reserve fund, which would then amount to £2,200, and to carry forward the small balance of £24 to next half year. In reality, as they would see, the Company were now in a better position than they had been for some years. They had their reserve fund at £2,200, they had no arrears of preference dividend, and the next thing they hoped to accomplish would be not only to pay their preference dividend and put something further to the reserve fund, but also to pay something on the ordinary shares. That led him to refer to the current half year, on which they had now entered. Their receipts for the first two months showed an increase for that period of £218. Of course, the month of September had not been completed, but they had twenty-nine days' receipts, and, as far as they could anticipate, they would be nearly the same as for the corresponding month of last year—about £1,000, a little under or over. If October, November, and December were only equal, supposing they had no increase on what they received in those months of last year, and that nothing occurred to the cables, they would be able to pay the 10 per cent. preference dividend, to pay a small dividend on the ordinary shares, and to put a further sum to the credit of the reserve fund. They had no reason to anticipate any interruption to the cables, and he thought they had every reason to anticipate that their returns for October, November, and December would be as good as they were last year. He thought it probable that they would have some increase of business from the marriage of King Alfonso should it take place next month. With regard to the International Telegraph Conference, it was held in London, and had in view the remodelling of the tariff and system of charges. It was thought desirable that the Company should be represented—indeed, it was necessary that it should be, and the result showed the importance of their being present at the deliberations. The conference, as they were aware, had adopted a word-rate for European messages instead of a minimum of 20 words, as adopted at the present moment. To this they had had to give their consent. It was difficult to know how this new system, which would come into operation on the 1st of April next, would affect their traffic, but it was thought likely to affect it beneficially, so far as they could form an opinion. It would be rather an inducement to the class of persons who were now in the habit of using the Company's lines to telegraph to Spain, and would, it was thought, induce a new class of persons who had only short telegrams to forward, but who did not now use the lines in consequence principally of a few words being charged the same as 20 words. The average length of a message being about fifteen words when the minimum was not enforced, the rate per word they had succeeded in obtaining from the Conference fully provided for this right—in other words, they would get from the 1st of April for fifteen words as much as they now got for twenty words. He would be happy to answer any question. He concluded by moving the adoption of the report and accounts.

Mr. Abraham Scott, a director, formally seconded the motion, which was carried unanimously without discussion.

The Chairman then declared the dividend for the half year on the 10 per cent. preference shares payable, less income tax, on the 1st October. He added that the dividend warrants would be posted that night.

Mr. Scott seconded the motion, and it was carried unanimously.

The Chairman said he might have stated in his opening remarks that any little improvement they had gained during the half year had been in spite of the continued depression of trade which prevailed in Spain as elsewhere. No doubt, with a general revival of trade, they would be greatly benefited.

Mr. Archibald McNicoll then moved, and Mr. M. S. Gilmore seconded, a vote of thanks to the chairman and directors.

The Chairman, in reply, said the Board would do their best for the interests of the shareholders.

The proceedings then terminated.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 1.	Business Done Week Ending Oct. 1. Highest.	Lowest.
Anglo-American Ordinary	56¾, 7	57¼	53⅝
Do. "B"	84½, ¾	84¾	82½
Do. "A"	31¾, 2¼	33¼	28¼
Brazilian	6 15-16, 7 1-16	7 1-16	6⅝
Cuba	7½, ¾	—	—
Do. Ten per Cent. Preference	15, 16	—	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	11¼, ¾	11⅝	11½
Direct United States	11¼, ⅝	11⅝	10¼
Eastern	7 15-16, 8 1-16	8	7⅝
Do. Six per Cent. Debenture	104, 106	—	—
Do. Five per Cent. do	102, 104	102⅝	102½
Do. Six per Cent. Preference	11¾, 12⅛	—	—
Eastern Extension	7 15-16, 8 1-16	8	7¾
Do. Six per Cent. Deb.	105, 108	107⅜	107⅜
German Union	7½, 8	—	—
Globe Telegraph and Trust	4 15-16, 5 1-16	5 1-16	5
Do. Six per Cent. Preference	11 5-16, 7-16	11⅜	11⅜
Great Northern	8⅝, ¾	—	—
Indo-European	20, 21	—	—
Mediterranean Extension	2½, 3	—	—
Do. Eight per Cent. Preference	9, ¼	9¼	9¼
Reuter's	9, 10	9 9-16	9 9-16
Submarine	224, 229	225½	225½
West India and Panama	1¼, ½	1⅝	1⅝
Do. Six per Cent. Preference	7¼, ⅝	7⅜	7¼
Western and Brazilian	2¾, 3¼	3	2¾
West. Union Seven per Ct. 1st Mt.	120, 125	—	—
Do. Six per Cent. Sterling	104, 106	—	—

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NOTES.

BLACKPOOL.—The success of the electric light has been so great that it has been decided to continue it in use.

CURRENTS IN THE MAGNETIC METALS.—Trève supports the theory of Ampère, that particular currents pre-exist in the magnetic metals, and that the effect of the battery is merely to determine the circulation and direction.

THE DUPLICATE AUSTRALIAN CABLE.—The s.s. Edinburgh, belonging to the Telegraph Construction and Maintenance Company, leaves Greenwich to-day with the Singapore section, and part of the Port Darwin section of the duplicate Australian cable.

CHEMICAL DISCOVERIES.—Eleven "new elements" have been brought forward since June, 1877, as claiming places in the list of substances which will not admit of decomposition. Surely, says the *Athenæum*, it is time that some admitted authority should examine and revise this list.

THE TELEGRAPH POCKET BOOK AND DIARY.—A memorandum has been addressed by Messrs. Letts, Son, and Co., to those who ordered this work for the coming year, stating that so little encouragement has been received in relation to this publication that they have been reluctantly compelled to discontinue it.

THE TELEPHONE IN BUSINESS.—The first to introduce the telephone into Durham, and to apply it to business purposes, is Mr. John Hill, miller, North-road. In his office, and in the hall of his residence, telephones are fixed, together with call apparatus. The connecting wire is carried from the office over the mill premises to the house—a distance of 100 yards.

LACE.—Debray uses wires of German silver in the manufacture of metallic laces. He colours metallic foils for the same purpose by depositing upon them iridescent films of oxide of lead. Litharge is dissolved in caustic alkali, and the resulting solution is decomposed by a current of constant intensity, the positive pole of the battery being in communication with the metallic surface to be coated.

THE TECHNICAL EDUCATOR.—We have received the first part of a new issue of this publication, and, believing that these serial works of Messrs. Cassell, Petter, and Galpin are calculated to do a large amount of real good, and induce many to obtain a deeper insight into scientific truths than they would otherwise obtain, we have much pleasure in calling the attention of our readers to this work.

MILITARY TELEGRAPHY.—In his important despatch of the 8th inst. to the India Office, General Sir F. Roberts says:—"I received greatest assistance throughout the day (the 6th inst.) from army signalling, under direction of Captain Stratton, 22nd Regiment." We presume that this refers to the heliographic system of Mr. Mance; as the wires of the ordinary field telegraph do not, we believe, extend further than the Shutargarden Pass.

THE CAPE CABLE.—The s.s. Scotia, just returned from laying a portion of the Australian duplicate cable, is now, with the Kangaroo, rapidly loading the remainder of the Cape cable off the Telegraph Construction and Maintenance Works at Greenwich. As soon as the loading is completed the vessels will sail, and it is expected that we shall be in direct communication with the South African colonies in the beginning of December.

EGYPTIAN TELEGRAPH STATISTICS.—According to a report just issued by the Ministry of the Interior, the statistics of telegraphs in Egypt read as follows: — Egyptian Telegraphs: Length of lines 7,841 kilos, length of wire 12,040, number of offices 168, number of telegraph instruments 302. English Telegraphs in Egypt—*i.e.*, those owned by British companies: Length of wire 1,456 kilos, number of offices 6, number of instruments 12.

GAS EXHIBITION.—The *Scientific Review* observes that the attempts to apply the electric light for general illumination have stimulated the gas companies to make great exertions. Recently they had, at Leeds, a very complete exhibition of gas apparatus for lighting and heating. Now the Gas Department of the Nottingham Corporation is to hold an an exhibition of gas appliances in the Mechanics' Hall from the 24th to the 29th of November.

ALARUM COMPASS.—Mr. H. A. Severn's Mariner's Compass causes an electric bell to be rung whenever the vessel is off her course. The captain of the ship sets the index hands to a certain angle, allowing the steersman a given latitude for deviation either to port or starboard. Should the ship be steered off her course beyond the limit allowed on either side an electric alarm bell rings, and continues ringing until the right course is resumed.

THE ALGIERS CABLE.—A slight but curious mishap occurred just at the point of completion of laying of this cable. The end was dropped, and in grappling for it the old cable was broken. The traffic was for a few days wholly carried on by the Eastern Telegraph Comany's cable, as both of the French Government cables were by this accident useless. We believe the new cable was, however, completed on Thursday, and the other cable is being repaired.

THE FORMATION OF HAIL.—Some interesting observations on this subject, by M. G. Oltramare, have appeared in the *Comptes Rendus*. M. Janin and other investigators have found that watery particles in mists may remain liquid at 6·8 F., or even at $-4°$ F,, provided there is no sudden shock. It is now shown that if, during this condition of "superfusion," there is a sudden discharge of electricity, the separating force disappears, and a union of particles takes place, forming hailstones of various magnitudes.

SUPERANNUATION AND INSURANCE.—It should not be forgotten that the Anglo-American Company has definitely decided to assist its *employés* in providing for a future, and

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we believe the Great Northern has also a scheme in actual work. The Eastern Company has the matter under consideration, and we have no doubt the whole of the submarine telegraph companies will ere long agree to some method of assistance, whether that method be similar to the one obtaining with railway companies, or with different working details. Should the gleams of trade revival be succeeded by a steady increase of commercial prosperity, the companies would be in a better position to act, and in the interests of a large number of our readers we trust their long-deferred hopes may soon be realised.

THE TELEPHONE IN GERMANY.—The *Cologne Gazette* states that by the help of the telephone, 685 localities have recently been brought into connection with the telegraphic system of Germany. The Siemens telephone is the particular form adopted, and it is found that the distance to which despatches can safely be sent by its help is 75 kilomètres. The Imperial Telegraph Office is, it is added, encouraging experiments with a view to perfect the telephonic apparatus, and hopes by its means sooner or later to be able to send messages to a distance of from 200 to 500 miles. The imperial telegraphs are allowed to be made use of by properly-accredited experimenters, and the Imperial Department has promised pecuniary rewards to such persons as shall succeed in extending the efficiency of the telephone.

TELEGRAPHIC CODE.—We have to announce that a list of 100,000 code words compiled from the several languages sactioned by the London Telegraph Convention, is in the Press, and will shortly be issued. The words are arranged in single alphabetical order, and thus the inconvenience of searching through eight languages in the event of a telegraphic error, will be obviated. The work will be issued by Dr. Ager, but the Telegraph Companies agree to accept the words, subject to a notice to him of any words that may from time to time be discovered to be unsuitable, he in turn stipulating to communicate such notice to all purchasers of the code. It is hoped that by these means a standard code will eventually be compiled. A part of the edition will be printed on one side only, so as to afford facilities to merchants wishing to adapt their codes to the rules of the late convention without the expense of a reprint.

NEW METHOD OF PRODUCING A COATING OF MAGNETIC OXIDE ON IRON SURFACES.—In the course of experiments with Bower's process for coating iron with magnetic oxide by a current of hot air, it was, according to Mr. G. R. Tweedie (*Chem. News*), found that the action was due to the combination of atmospheric oxygen with the carbon of the iron to form carbonic anhydride, which was then reduced by the iron according to the well-known equation $4CO_2 + Fe_3 = Fe_3 O_4 + 4CO$. Hence this process was found to be unsuitable for coating wrought iron or steel. The mode of procedure now adopted is to heat the articles to be coated in a current of impure carbonic anhydride, obtained by the combustion of small coal. By this means a coating of magnetic oxide is obtained slightly contaminated with red oxide, the conversion of which into magnetic oxide is then effected by adjusting the air supply of the furnace, so as to substitute a current of carbonic oxide for the carbonic anhydride, $3\,Fe_2 O_3 + CO = 2\,Fe_3 O_4 + CO_2$. The coating thus produced is very hard, homogeneous, and withstands ordinary oxidising influences perfectly.

THEORY OF THE MICROPHONE.—Prof. Julian Ochorowicz considers the chief causes of the action of all possible forms of microphone to be a mechanical movement of its parts, a change in the points of conductivity, and a change of resistance—three essentials which result from one another. He holds that there is no increase of sound by the microphone, as usually understood. All sounds are weakened by the microphone, and are transmitted only when the source of sound is in direct contact with the microphone or its stand. The microphone is less an instrument for transmitting sound than for transforming mechanical movement into sound. The intensity of a sound is, therefore, directly proportional to the energy of the mechanical movement accompanying the sonorous waves, or, as a necessary consequence, to the changes of resistance in the microphone. The distinctness of articulate sounds transmitted by the microphone is in inverse proportion to their intensity; for a loud sound tends to interrupt the current completely, and thus to prevent the transmission of articulate sounds. This is the chief hindrance to increasing at pleasure the loudness of the sound. The loudness of the sound is also dependent on the strength of the current.

OXIDATION OF ALCOHOLS BY ELECTROLYSIS. BY A. RENARD. ("Annales de Chimie et de Physique," vol. xvi., p. 289.)—Electrolysis has been chiefly studied in its relations to mineral chemistry. Excepting the electrolysis of organic acids and their alkaline salts, the application of electrolysis to organic chemistry has been neglected, although these isolated experiments have given remarkable results. The author has investigated the subject of the oxidation of the principal alcohols by the gas yielded during electrolysis, and has obtained results of so favourable a nature as to lead him to prefer this method of oxidation to the ordinary processes, as it has the advantage of being effected at a low temperature and in the presence of weak reagents, and allows, therefore, of more easily learning the different phases by which the substances become oxidised before they are completely consumed and transformed into the ultimate products, carbonic acid and carbonic oxide. According to Berthelot's recent experiments, electrolysis, besides yielding oxygen and hydrogen, also produces persulphuric acid, ozone, and oxygenated water; under the conditions of the author's experiments these products either did not occur or their effect was rendered null. The phenomena are therefore confined to the decomposition of the acidulated water with formation of hydrogen and oxygen, and the fixation of the oxygen upon the alcohol. The hydrogen disengaged was found to have no effect upon the alcohols experimented with, since when its electrode was enclosed in a porous vessel the alcohol contained therein was not subject to any alteration. The author considers that this method of oxidation might be advantageously applied in the study of numerous other organic substances. The battery employed was of Bunsen elements of about 1·5 litre capacity, in which the zinc cylinder was replaced by a cylinder of cast iron, carrying a lug, to which is riveted a copper strip, curved at right angles, and immersed at its free end in a mercury cup, formed in the carbon of the adjoining cell. This battery can be rapidly mounted, and is economical, owing to the absence of amalgamation and to the substitution of iron for zinc. Each iron cylinder weighs 4·4lbs., and will suffice in constant use for a period of two months; the quantity of electricity furnished being about three-fourths of that given by a battery constructed with zinc cylinders.—*Trans. Inst. Civil Engineers.*

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NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONTINUED FROM P. 238.)

III.

Mr. Willoughby Smith gave in his paper five diagrams, which we here reproduce, referring to arrangements for signalling through long cables which were patented by Mr. Varley in 1862. In Fig. 4, it will be seen that the receiving end of the line is con-

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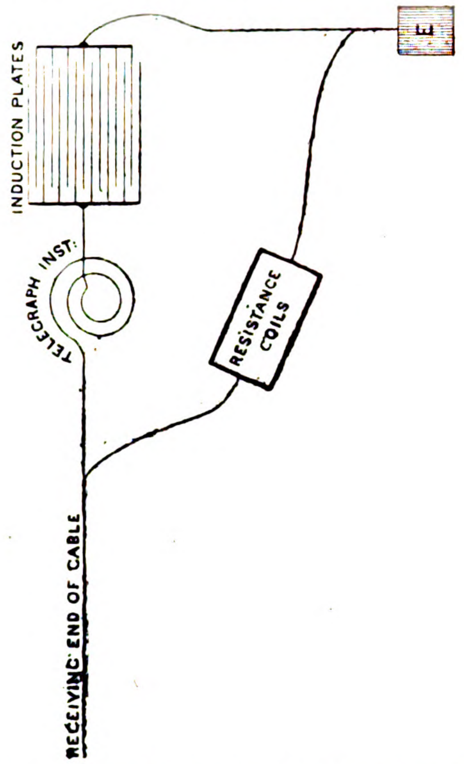

nected to earth through a resistance coil (which was stated by Mr. Varley to be more effective when wound on a large iron core) and that it is also connected, through the receiving instrument, with one side of a condenser of which the other side is connected to earth. This arrangement is of interest as being, we believe, the first in which the use of condensers for cable signalling was suggested, and also from the fact that in it an evident attempt is made to utilise the "inverse current on making contact," and also the coil current, or "direct current on breaking contact." It should be borne in mind that, when these arrangements were devised, the impression everywhere prevailed that an Atlantic cable could be worked only by very powerful currents of electricity. And an ingenious mind, acquainted with the facts in relation to what Faraday termed "the induction of a current on itself," might readily suppose that the arrival current would be retarded, or arrested for a minute space of time, by the resistance coils indicated in the figure, whilst it would freely pass through the receiving instrument to charge the condenser, and thus give a signal; and further, that this signal would be "sharpened" by the subsequent discharge of the condenser through the coils in question, serving also to discharge the cable. But, as the writer of these notes discovered to his cost, in a lengthened experimental trial of some proposed improvements in signalling which appeared *primâ facie* to be very efficacious, the effect of electro-magnetic retardation is not exhibited when a coil is placed, as shown, at the receiving end of a long submarine line. This is due to the very *gradual* rise of tension at the distant end of a conductor of high resistance and charging capacity, when such a conductor is charged from a source at the near end. For the effects of electro-dynamic induction to be strongly manifested, the current must be suddenly produced and suddenly arrested—a fact which the makers of dynamo-electric machines, as well as the makers of induction coils, would do well to keep in view. Moreover, by the introduction of Sir W. Thomson's mirror galvanometer as a signalling instrument, cables became readily worked by what Mr. Varley once termed the "ghost of a current;" and such a current, as Mr. W. Smith pointed out, is totally inadequate to produce perceptible electro-magnetic induction effects.

In Fig. 5, we have the same arrangement at the receiving station; whilst at the sending station the line is insulated from earth by a condenser. Here Mr. Varley comes very near indeed to the present system of working long cables, in which the line is normally insulated from earth. We learn from Mr. W. Smith's paper that Mr. Varley was, somewhat unaccountably,

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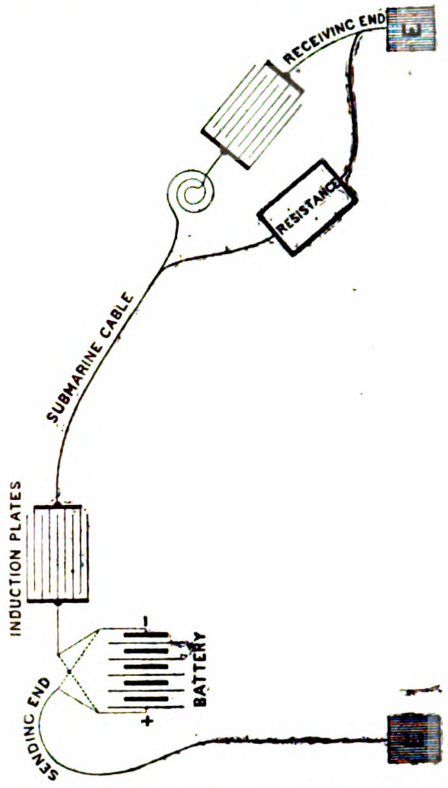

under the impression that the condenser would be useless without the adjunct of the resistance through which, together with the receiving instrument, it is circuited.

In Fig. 6 the condenser at the sending end is circuited through

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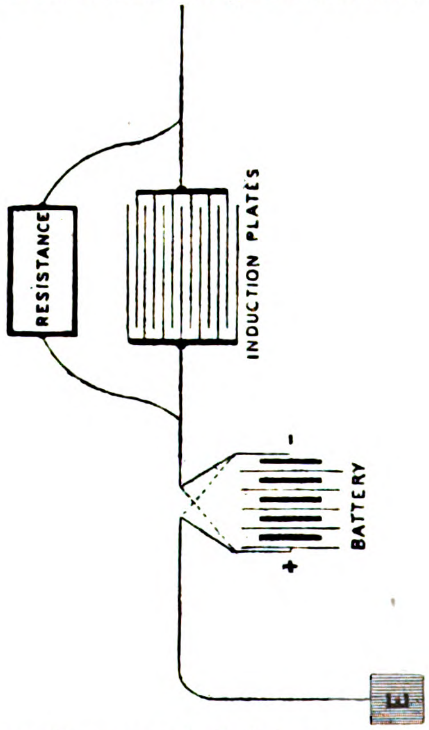

a resistance, presumably possessed of electro-magnetic inertia. We must confess that we cannot perceive the object of this arrangement, the results of which would appear to be from every point of view undesirable. In effect, the resistance would in no wise facilitate the sending of a current to line; whilst the coil current would oppose the discharge of the latter, by contact with earth at the sending end, or the reversal of the current.

In the next figure the object seems to be the sending of a current to line for a very short period of time, *i.e.*, until the magnetic inertia of the induction coil is overcome, or its inverse cur-

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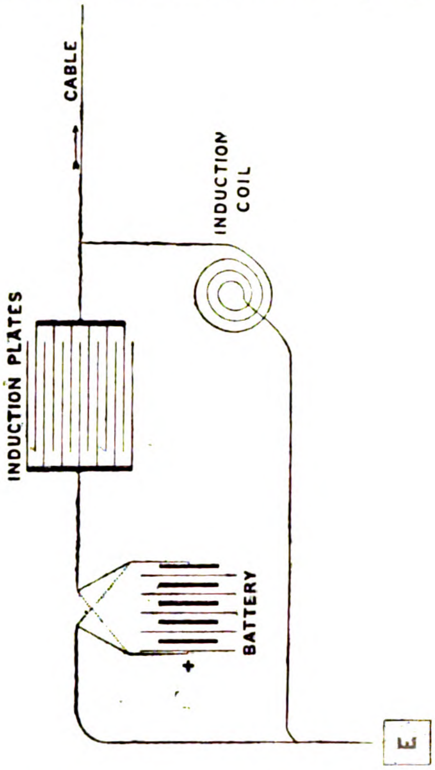
rent on making contact has ceased, and to allow of the cable being subsequently discharged to earth. The arrangement might



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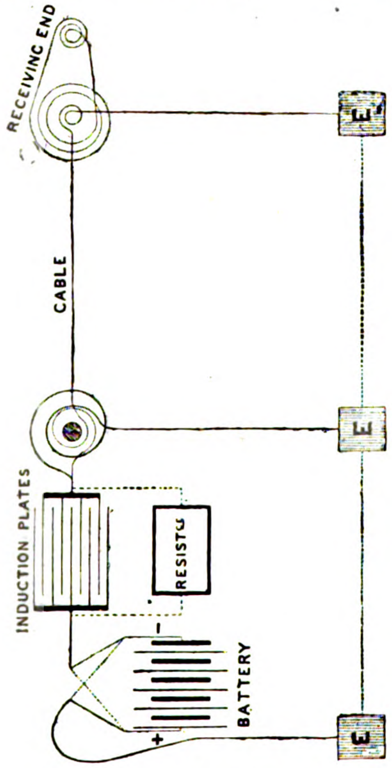
possibly be valuable when a charge requires to be limited by means not wholly dependent upon the duration of a contact.

In Fig. 8 there appears to be a secondary as well as a primary



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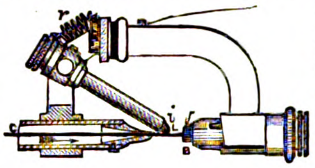
coil at the sending and at the receiving end. Supposing the magnetic inertia of the resistance through which the condenser is circuited to be considerable, a direct current by induction would be transmitted during a definite period of time through the primary coil at the sending station, and would be succeeded by a direct current from the battery through the resistance. It is difficult to perceive the object of this contrivance, which seems to fulfil no useful purpose, since, after all, the duration of the current is limited only by the contact with the battery. Through the secondary circuit at the sending end an induced current of limited duration would pass to line, completing its circuit through earth at the receiving station. But there this current apparently generates a tertiary current which acts upon the receiving instrument. This arrangement is perhaps of historical interest as containing the first suggestion of the working of a receiving instrument by the effect of current induction, which affords a ready means of increasing the sharpness of signals.

After adverting to these arrangements, Mr. Willoughby Smith says :—" I am not aware that any one of these various systems of Mr. Varley was ever practically applied to either a submarine or subterranean line; but if so, I imagine the results were not satisfactory, for on the 6th July, 1865, just before the starting of the expedition to lay the cable across the Atlantic between Valentia and Newfoundland, Messrs. Thomson and Varley conjointly patented 'Improvements in Electric Telegraphs,' Mr. Varley being electrician to the Atlantic Telegraph Co., and Sir William Thomson scientific adviser to the same Company."

NEW ELECTRIC LAMP.

BY THE INCANDESCENCE OF CARBON (REGNIER SYSTEM).*

It will be remembered that the principle of the Regnier lamps consists in maintaining incandescent a thin rod of carbon, by the passage of a voltaic current traversing a limited portion of its length, included between an end contact-piece against which



it abuts, and a lateral contact-piece against which it rubs as it progresses. We have kept our readers informed of the various arrangements devised by the inventor to carry out this original principle. Continuing to perfect his system, M. Regnier has just contrived a new electric *bec* still more simple than the preceding forms. This new form of lamp is represented in the accompanying figure.

The carbon C moved in the direction of the arrow by any suitable mechanism, abuts on the end contact-piece B. The lateral contact-piece L, mounted at the extremity of a lever, presses against the carbon by the action of the spring *r*, and limits the incandescence of the rod to the space between *i* and *j*.

The end contact-piece B is mounted in a contact-carrier fixed by a bayonet joint within the lower socket of the burner. To insert the carbon in the lamp, the contact-carrier is withdrawn, leaving the opening of the tube exposed; the carbon is inserted within the latter, the end contact-piece is replaced, and the lamp is ready for working.

The incandescence, as we have observed, is exhibited between *i* and *j*, over a length which may be varied between 4 and 8 millimètres. The light obtained is from five to twenty Carcel burners per lamp, according to the intensity of the electric current and the length of carbon over which the incandescence is made to extend. With a battery of eight flat Bunsen elements (on the Rhumkorff model) a light equivalent to about twelve Carcel burners is produced. When the electricity is supplied by a magneto-electric machine, from three to five lights, each equivalent to from eight to fourteen burners, may be obtained; showing a duty of between thirty and forty Carcel burners per horse-power.

The electric "burner" being supplied, it was easy to adapt it to lamps of various forms. M. Regnier has constructed some in which the carbon is moved vertically by the action of a counter-weight or of a hydrostatic push, also another form, with a "drum," working in any position, and an apparatus for suspension, which is the simplest of all.

MR. RICHARD HERRING AND THE TELEGRAPH DEPARTMENT OF THE POST OFFICE.

[The following recent correspondence upon this question has taken place. As we have previously dealt at some length on this subject, we take this opportunity of completing the case so far as it has been carried at present.—ED. *E.*]

27, St. Mary's-road, Canonbury, 26th May, 1879.

TO THE RIGHT HONOURABLE LORD JOHN MANNERS, M.P., POST-MASTER-GENERAL.

MY LORD: As your lordship has not replied to my letter of the 26th ultimo, and as the matters therein referred to are of very great importance,

* From *La Nature*.

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I would respectfully ask your lordship to favour me with the information requisite to enable me to comprehend the reason of your lordship's silence. I assume that there can be no misconception on my part as to the privilege of the subject to appeal to the Sovereign, because the Sovereign, by the Secretary of State, has acquiesced in the nature and sufficiency of my memorial, and has requested your lordship to give it attention. I assume, likewise, that as the facts laid before the Queen in my memorial are not disputed by your lordship, or by your lordship's secretary, that your lordship can have no reason to urge in opposition to the wishes of Her Majesty, conveyed to your lordship by Her Majesty's command. Upon these assumptions I would, therefore, urge my appeal upon your lordship's honourable consideration; and I venture to submit to your lordship that stronger grounds for appealing against palpable injustice never existed.

Your lordship knows that the Post Office has broken faith with me over and over again, and has thereby subjected me to an unnecessary and cruel outlay of both money and time.

Your lordship knows that the Post Office promised to make a full and fair trial of my system of telegraphy, and that it never kept its promise.

Your lordship knows that the Post Office invited me to make costly preparation for such trial, and that the trial has not taken place.

Your lordship knows that the Post Office informed me that it had engaged two scientific gentlemen, unconnected with the Department, to meet two other scientific gentlemen on my behalf, and your lordship knows that such meeting has never occurred.

Your lordship knows that at the solicitation of the Post Office, I engaged and paid two eminent scientific gentlemen to represent me at the proposed trial, and that the Post Office has never appointed a time for the trial, or for any meeting whatever of the referees.

Your lordship knows that the Post Office arranged and signed terms of reference, and that it has never acted upon them.

Your lordship knows that the Post Office promised to adopt my system if the trial proved satisfactory, and also that the Post Office obtained possession of my instruments under a written promise to proceed with the trial, and your lordship knows that the Post Office has not kept faith with me in either instance.

Your lordship knows, finally, that I am in need of the money which the Post Office has improperly induced me to expend, and that my wasted time has been of at least equal value to my wasted money

Sooner or later these facts must undoubtedly impress themselves on your lordship's mind, and prompt a conscientious regard, and I therefore beg your lordship to spare me the pain of repeating them.—I remain, my lord, your obedient servant, RICHARD HERRING.

The Right Hon. Lord John Manners, M.P., Postmaster-General.

As this letter received no attention, I enclosed a copy of it, on the 24th June, to Her Majesty's private secretary, Lieut.-Gen. Sir Henry Ponsonby, respectfully soliciting his advice, and on the 7th August I again wrote to Sir Henry Ponsonby as follows:—

27, St. Mary's-road, Canonbury, 7th August, 1879.

SIR: Two months since I wrote to ask your advice as to the course I ought to pursue in relation to my petition presented to Her Majesty the Queen two years ago by the Secretary of State, and which petition was referred by Her Majesty to the Postmaster-General, Lord John Manners. As I have not received any reply to the inquiry I then addressed to you, I once more respectfully solicit your attention.

Sir Thomas Biddulph wrote to me a short time before his death as follows:—"In reply to your letter, and also to one forwarded to me, which you addressed to Prince Leopold, I am desired to say that the Queen entirely refers the subject of your petition to Lord John Manners."

Since that time I have frequently written to Lord John Manners without receiving any reply from him; and I am at a loss to conceive the use of petitioning the Queen—or, at least, of Her Majesty referring my petition, as she has done—unless the supplementary information which was furnished to me by the Right Hon. George J. Goschen, M.P., is equally necessary to that which was furnished to me by the late Sir Thomas Biddulph.

Mr. Goschen wrote to me as follows:—"If a petition is referred to the head of a department, such as the Postmaster-General, it would be for reference and not for decision. *The advice* with regard to the decision would have to be given by the Secretary of State."

Hence, it is quite clear that if any undue delay has arisen, either on the part of the Postmaster-General in considering, or on the part of the Secretary of State in advising, it rests solely with the Queen, or with those who represent Her Majesty, to call attention to such delay with a view to the petition being dealt with in a reasonable time.

I submit these observations with all possible respect, and I should be much indebted by the prompt assistance which it is in your power to afford.—I have the honour to remain, Sir, your most obedient servant,

Lieut.-General Sir Henry Ponsonby, RICHARD HERRING.
Private Secretary to the Queen.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MADAM: In approaching your Majesty with every sentiment of esteem becoming a dutiful and loyal subject, I desire most humbly to submit to your Majesty the enclosed communications which I have addressed to Lord John Manners and to Sir Henry Ponsonby without receiving in either case a reply or any acknowledgment. I beg leave at the same time to assure your Majesty that I am utterly ignorant of any neglect on my part to fulfil faithfully my duty, and that I am equally ignorant of any conceivable reason for the treatment which my petition to your Majesty has received. It was approved by your Majesty's Secretary of State and by him presented to your Majesty. The facts set forth in it were most serious, and to myself most ruinous. Every day that passes without restitution being made to me, is a palpable addition to the burden of my complaint. As I am unconscious of any further steps which your Majesty might wish or expect me to take, I humbly solicit your Majesty's counsel and advice in the event of your Majesty's pleasure enjoining any further act capable of my performance.

My petition makes clear and definite statements, and I doubt not my constitutional appeal to your Majesty, as the supreme fountain of justice, will render it equally clear that your Majesty is not personally indifferent to the many wrongs which have been inflicted with such deliberation upon your Majesty's loyal and dutiful subject, RICHARD HERRING.

27, St. Mary's-road, Canonbury, 23rd August, 1879.

TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

SIR: Having submitted the petition referred to in the enclosed correspondence to the Secretary of State for the Home Department, and having obtained his approval and likewise his official assistance in laying that petition before Her Majesty the Queen, I am advised by counsel that I am "entitled by the Constitution to have the merits of my petition considered by the Sovereign in the exercise of her Royal prerogative, unless the subject matter of the petition is of sufficient gravity or public concern to necessitate the advice of the Privy Council or the Cabinet." Counsel adds that "although constitutionally the Queen can do no wrong, practically she might do a great deal of good, and there could be no objection to taking a line which indicated that the Sovereign failed to do as much good as might reasonably be expected from her." Your Royal Highness will, I think, agree with me that there cannot be two opinions as to the gravity and public concern of the subject matter of my petition, a copy of which I also enclose. Still the remedy is so apparent, so simple, and so imperatively required, that one way or other it would appear reasonable to anticipate much speedier attention being paid to the case than it has received, unless a resolve has existed to permit and perpetuate the injustice.

In any case I would respectfully ask your Royal Highness to confer upon me the favour of using your high influence to prove the needlessness of such deceitful and dishonourable conduct in English Departmental Government.

"'T is lacking courage to contend with wrong
That makes the evil grow so high and strong."

Humbly, therefore, would I solicit the assistance and advice of your Royal Highness, and I beg leave to subscribe myself, with every sentiment of esteem, Your most obedient servant,
RICHARD HERRING.

27, St. Mary's-road, Canonbury, 6th September, 1879.

Marlborough House, Pall Mall, S.W., 16th September, 1879.

SIR: I am desired by His Royal Highness the Prince of Wales to acknowledge the receipt of your letter of the 6th instant and of two enclosures.
I am, Sir, your obedient servant,
R. Herring, Esq. FRANCIS KNOLLYS.

27, St. Mary's-road, Canonbury, 17th September, 1879.

SIR: I beg you will do me the favour to assure His Royal Highness the Prince of Wales that I am much gratified by the honour of an acknowledgement of the receipt by him of a copy of my petition to Her Majesty the Queen, and of the three letters relating thereto with which the petition was accompanied. In the absence of any intimation from His Royal Highness to the contrary, I trust I may count upon the exercise of His Royal Highness's influential assistance, the favour of which I solicited. Awaiting patiently the result, and with great respect, I am, sir, your obedient servant,

Francis Knollys, Esq., C.B., RICHARD HERRING.
Private Secretary to H.R.H. Prince of Wales.

Royal Yacht Osborne, Portland, 18th September, 1879.

SIR: I have had the honour of laying your further communication, dated the 17th inst., before the Prince of Wales, and I am desired to inform you, in reply, that it will not be in the power of His Royal Highness to interfere in the matter to which you refer.—I am, Sir, your obedient servant,

R. Herring, Esq. FRANCIS KNOLLYS.

27, St. Mary's-road, Canonbury, 19th September, 1879.

SIR: As it is not "in the power of His Royal Highness to interfere in the matter," may I trouble you to ascertain what course His Royal Highness would recommend me to adopt. I much regret the misconception created by your first communication, especially as your letter just received withholds the advice I solicited, and also withholds any suggestion to lessen the deplorable impression created by a fruitless Memorial to the Queen upon palpable unfaithfulness in the public service. Of course, I cannot attribute such indifference to Her Majesty's personal willingness; at the same time, I cannot attribute to His Royal Highness so much indifference as to permit the Queen to remain uninformed of a grave matter affecting the royal prerogative. Shifting statesmen are not impelled by the same urgent considerations as His Royal Highness to keep a jealous watch over the Sovereign's privileges. Moreover, the Litany of the National Church embodies the national aspiration when it supplicates the King of kings for "righteousness and holiness of life" on behalf of the nation's Sovereign. But unworthy and infamous deeds, systematically enacted in the Sovereign's name, whether with or without the Sovereign's knowledge, alike render the nation's supplication nugatory, and promote national hypocrisy. These obvious conclusions present themselves in opposition to further inactivity, and will not fail, I trust, to insure your good offices in the direction I have indicated. I may add, further, that there appears to be no other course left open to me than that which I now take. The Chairman of the City Carlton Club, of which the Duke of Richmond is the President, wrote to me, suggesting that I should "bring the matter before Parliament." I had applied to the Right Honourable J. G. Hubbard, M.P. for the City of London, and his answer was, "As an ex-Cabinet Minister, Mr. Goschen is far more likely than I am to prevail with the department from whom the redress is demanded. I will move for any returns you desire, if the Government assent, but I could not, as one of their supporters, urge the motion adversely to their decision." I afterwards saw Mr. Goschen, and pressed him to move in the matter, and as a preliminary step he agreed with me that it would be important to get the Home Secretary to lay my petition to the Queen before the House of Commons. Within three days, however, of that interview, I received a letter from Mr. Goschen, stating, "I learn from the Home Secretary that memorials addressed to Her Majesty are never laid before Parliament." Again I sought high and impartial opinion of counsel, which was given as follows:—"Your complaint is against a Government Department, and it is to the Crown that your complaint is properly directed." Thus, as I have already said, there appears to be no other course open to me than to urge again and again, directly and indirectly, that my memorial, approved by the Secretary of State, and by him presented to the Queen, should receive the attention it solicits, and to which it is entitled. With many apologies for troubling you. —I am, sir, your obedient servant, RICHARD HERRING.

Francis Knollys, Esq., C.B.,
Private Secretary to H.R.H. Prince of Wales.

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THE ELECTRICIAN.

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CHEAP LOCAL TELEGRAMS.

A few weeks ago the Newspapers gave prominence to a paragraph announcing certain changes in contemplation by the Post Office authorities. Foremost among these changes was a proposal to establish a Sixpenny rate for Telegrams within the Metropolitan area. We have been unable to discover that there was the least foundation for the rumour. But it did undoubtedly embody the hopes and desires of certain telegraphic reformers whose aspirations will fall short of realisation so long as the shilling rate prevails. A sixpenny rate should, in their opinion, be first introduced in large towns, to be followed by a like reduction all round. There is no present intention, apparently, on the part of the Post Office, to accede to these demands; but paragraphs of the kind we refer to are a species of agitation in prophetic guise; and as prophecies always have a tendency to fulfil themselves if steadily persisted in, it may be worth while to discuss this subject before it advances any further.

As a lever for introducing a sixpenny rate throughout the United Kingdom, the adoption of half rates for towns would indeed be a clever stroke of policy; for it could, we think, be easily shown that if a sixpenny tariff were tolerable for towns it ought to be extended to the country at large. All the arguments in favour of uniformity would tell that way; and as there would be no difficulty in proving that a telegram from Blackwall to Paddington costs as much to transmit as one from London to Edinburgh, the case for a general reduction would be irresistible. There are many people however—amongst whom we may class the newspaper paragraph writers themselves—who, while seeing no objection to a cheaper town tariff, would hesitate to recommend a rate so low as sixpence for the whole country; and to such persons we commend the view we have just propounded as against tampering with the tariff at all.

The advocates of an uniform sixpenny rate are probably not so numerous, at all events they are not so enthusiastic, as they were a few years back. The Shilling rate has not proved so successful, financially speaking, as to encourage the notion that a sixpenny rate would be remunerative. Except by a strained interpretation of its balance sheet, the Postal Telegraph administration of this country cannot be called a paying concern; and to whatever causes its financial shortcomings may be attributed the price of its telegrams is certainly not among the number. Taking into account the geographical features of the British Isles, the price of labour, and the value of money, our tariff will bear favourable comparison with any tariff in the world. There is no reason to suppose that a lower rate would attract even a proportionate increase of messages; nor that the existing staff would be able to cope with much more work than is disposed of at present. These facts having become more and more prominent of late, the advocacy of a reduced tariff is now confined to a few restless spirits who would plead for the cheapening of penny ices, salt, or lucifer matches, if any official capital were to be made out of it.

The half-rate system proposed for towns, however, is supposed to stand on a different footing, and is in some quarters alleged to be capable of being argued independently on its merits. Disregarding the actual cost of transmission, it is urged that the distances within town limits being so small the cost ought not to be so great; that whether it ought or ought not, the public, not appreciating the fact, deem it a grievance that a telegram from one street to another costs as much as from one town to any other; and further that as the public service is for the public convenience all other considerations should be set aside for its satisfaction. It may be admitted at once that if there were any real grievance—that is to say if there were a disposition to send telegrams within town limits, checked only by the cost, there would be a good case for reducing it. But we very much question this assumed desire on the part of town residents, and we distinctly deny the convenience they would enjoy by any attempt to meet their wishes.

In obedience either to the demands of town populations, or to some kind of logical consistency, a local tariff has been adopted in three continental countries. Italy, Austria, and Portugal afford we believe the only examples of a half-rate for local traffic. The tariffs of these countries, however, as a whole are less liberal than our own; and neither there nor elsewhere, do we find the postal system so expeditious as

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here. The postal deliveries of our towns, and notably those of London, are in fact the rivals of the telegraph, and for reasons sufficiently obvious to the practical telegraphist, electrical communication will always have a poor chance of competing successfully with a well organised town postal system. One bold suggestion, emanating from a brain more fertile than exact, has been put forward to reduce the town tariff and dispose of the increased traffic by an elaborate network of pneumatic pipes. We make no objection to the proposal itself,—but it has nothing to do with telegraphy. The puff of wind which carries twenty sealed envelopes to their destination is not electricity; nor are the contents in any sense telegrams. As supplementing the letter-cart such a system may, and at no distant date probably will, lend fresh speed to the "town delivery"; and the prospect of a remunerative reduced rate for telegrams is thereby proportionately diminished. For strange as it sounds to unprofessional ears the fact is, of course, that distance has little or nothing to do with the speed of a telegram whereas it is everything in respect to a letter.

We have said that there is no general demand for a more perfect and cheaper local telegraph system; but so far as it is patronised at present it is, we believe, a very thankless and unprofitable business. Some people do, it must be owned, imagine they can send a telegram almost anywhere quicker than they can despatch a *commissionaire* or a letter by post. In reality the conditions must be very favourable for this to be the case when the distance does not exceed a few miles. Nor could any reasonable multiplication of offices, or increase of wires and staff alter this state of things for the better. Every fresh pretence of doing mere messenger duty by Electric Telegraph will result in disappointment to the public and loss to the Department. Electricity will always retain its pre-eminence for long distances, but its employment for short distances—except in direct communications between individuals—is like chartering steamships to cross ditches. To give satisfaction the town telegraphs would have to be at least as expeditious as the extra town systems, and this is simply impossible; for, beyond the limits of important centres, the number of transmissions and the time occupied in final delivery would generally involve greater delay than the despatch by messenger over the whole distance. The adoption therefore of a sixpenny rate for the supposed convenience of urban populations would give countenance to a popular delusion which must result only in failure and popular clamour. In the time of the old Companies it was we believe no uncommon thing to warn would-be senders of local telegrams that the process was very slow; and as the facilities have not, nor ever can be, materially improved, the present owners of the Telegraphs, so far from inviting this kind of traffic, would do well to discourage it. They scrupulously warn us of every half hour's delay to any out-of-the-way spot in the Kingdom, and we do not see that they are called upon to expose themselves to perpetual complaints from delay which, in respect to town telegrams, is chronic and incurable.

The history of the penny postage, recalled to our recollection by the death of Sir Rowland Hill, will help us to understand why delays such as we are referring to are incurable. That gentleman ascertained that the main cost of a letter was incurred in collecting, charging, and delivery. The cost of transmission counted for next to nothing. Substitute time for cost, and the illustration will apply to telegrams. Letters are despatched in bulk; telegrams involve a separate transaction for each. The time occupied in the case of telegrams is, broadly speaking, the same whether their destination be near or far off; and the delivery by hand is the same also whether the telegraphic distance has been great or small. Thus a message sent five hundred miles may reach the addressee as soon as one sent as many yards. The actual operations of telegraphing have been the same for each; the superadded delays have been great for both alike; but whilst the delay in the case of the long distance telegram is unnoticed or condoned, that upon the short-distance telegram is simply intolerable. Nothing short of putting every street in direct telegraphic communication with every other street would alleviate the grievance; and as the cost would be enormous, the maintenance ruinous, and the benefit highly problematical, a scheme of that sort is not worth discussing.

We have said that our tariff is already a very liberal tariff; in one respect indeed it is too liberal. The free addresses which, contrary to the custom of all other nations, are permitted in this country are a heavy tax on the resources of the administration. The English telegraphing public however have so long been accustomed to the privilege that they will never probably relinquish it without some equivalent advantage. We only refer to it here as one of the hindrances to any reduction of our tariff whatsoever. The advocates of a half-rate town tariff are, strange to say, also the staunch upholders of free addresses. To us it is perfectly certain that so long as this portion of the despatch is transmitted at the expense of the Post Office—that is to say, so long as the permissible number of words is twenty-eight or more instead of twenty, a reduction in price is impossible. If however a uniform sixpenny rate is contemplated as one day inevitable, it might be well to experiment in towns first—allowing, of course, only twenty words, at most, including the addresses.

THE LIGHTING OF RAILWAY STATIONS BY ELECTRICITY.

The Lontin electric light, which appears likely to be adopted for the illumination of the stations of the Metropolitan Railway Company, has already been employed with equally brilliant and satisfactory results at the Paris termini of the Paris, Lyons, and Mediterranean, and of the Western Railway Companies. It is found that the use of the electric light allows of the lanterns hitherto carried by the porters being dispensed with; since not only is there a total absence of the dark shadows which were so much dreaded when the light was first spoken of, but even the space between the carriages is fairly illuminated. And in large goods stations especially, the accidents and losses which represent in the aggregate so large a sum are very greatly diminished by this means. The lighting in the above instances is carried out under contract by the Electric Generator and Light Company, who own the Lontin patents.

In London, the above light has been for some time past under experimental trial at the Aldersgate-street underground station, where, on Monday last, a number of gentlemen interested in the application of electricity for lighting purposes were received by Mr. M. Fenton, the Secretary of the Metropolitan Railway Company, who explained to them the arrangements for obtaining the eight lights by which the station is at present illuminated. We need scarcely observe that these lights give a result greatly superior in brilliancy to that obtained by means of gas. On this point the Railway authorities are fully satisfied. But what is of even greater present interest is the statement of the Electric Generator and Light Company that the former result can be obtained at no greater

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cost than that which was incurred for the comparatively dim gas lamps, and that, should the Railway Company be satisfied with less brilliancy, the cost for electric lighting would be less than that for gas. The lights used at Aldersgate-street have an illuminating power of about 600 candles; and it is reckoned that the cost of the coal and the carbon to maintain such a light is under 3d. per hour. A valuable feature in this system is that any light can be regulated or extinguished without affecting the other lights produced by the same dynamo-electric machine. The form of lamp here in use burns for four hours; but, when necessary, lamps on this system may be constructed to burn for a much longer period. The lamp has undoubtedly been greatly improved since it was first set up outside the Gaiety Theatre, and now the light leaves little to be desired in point of steadiness. Under these circumstances, we think it probable that this system of electric lighting may very shortly be extended to the Moorgate-street and Farringdon-street stations, and that the use of dynamo-electric machines for illuminating purposes may gradually receive an extended application in metropolitan and other railway stations where either the goods traffic or the passenger traffic is considerable.

CORRESPONDENCE.

PIONEERS IN TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may interest many of your readers to know that a gentleman is still living who was articled to Mr. Edward Davy and assisted him not only in the arrangements in "Exeter Change," referred to in the letter from Dr. Cornish which I will append, but who also assisted him at that time in laying a practical line of telegraph for experimental purposes around the inner circle of the Regent's Park, permission for the latter having been granted to Dr. Davy by the Commissioners of Woods and Forests. All this was long prior to anything narrated by Mr. Wilkins in your last impression, and, on the death of Professor Morse, I wrote to Dr. Cornish hoping to obtain further valuable information of which, unfortunately, death has now deprived me. However, it appeared certain that Morse obtained his idea from Davy. Morse left England in 1832, and on his homeward voyage to America he discussed for the first time, as he himself admitted, his arrangements for telegraphing. It is likewise certain that Davy invented the "Relay," which he termed first a "Renewer." These are his own words, written at the time:—"It has been found that electric currents, in passing through considerable lengths of metallic circuits, decrease in energy, consequently, where the point from which the communication or signal is given is very distant from the point or place at which the communication or signal is received, it is necessary to have some means of overcoming this difficulty, and it has been proposed to have a number of apparatus at comparatively short distances, and persons to attend thereto, to receive and transmit the various communications on from place to place (in like manner to what is now done in communicating from place to place by telegraphs depending on sight), till the communications or signals reach the destined place, which is necessarily an expensive means, and attended with greater liability to error in making a communication. Now, by my invention, I so arrange the metallic circuits that at the requisite intervals the apparatus itself will bring into action a succession of wires, having their own batteries, which I call Renewers." Dr. Cornish's letter, to which I have referred, is the following:—

The Vicarage, Ottery St. Mary, October 13, 1871.

SIR: Immediately on the receipt of your letter I put myself in communication with the family of Mr. Edward Davy, and his elder brother, Mr. John William Davy (who is a medical practitioner in this town) promises to supply you with full particulars of his brother's discovery in telegraphy. I remember the exhibition of a model in illustration of his system in Exeter Hall (or the Egyptian Hall) *about* the year 1830. Mr. Edward Davy has resided abroad for many years, and is, *I believe*, connected with the Assay Office at the Sydney Mint in Australia, but I am not positive on this point. His father was not a clergyman, but a medical man of very long standing in this parish.—Yours, &c.,

SIDNEY W. CORNISH, D.D., Vicar of Ottery St. Mary.

I may mention that Mr. Edward Davy was a member of the College of Surgeons, and also of the Apothecaries' Company. He carried on his profession in the Strand, but his telegraphic experiments were chiefly manipulated in a laboratory at the back of the chemist's shop occupied by Mr. Pedler, in Fleet-street. Unfortunately his ardour cost him £30,000, and he had to go abroad, whence he never returned.—Yours, &c.

RICHARD HERRING.

27, St. Mary's-road, Canonbury, Oct. 7, 1879.

STATISTICS OF THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of last week, under the above heading, you published the remarks of Mr. James Shoolbred on electric lighting, as made by that gentleman before the Association of Municipal and Sanitary Engineers at Liverpool. Whilst agreeing with Mr. Shoolbred's remarks as to the cost of the electric light, I must differ from what he said about the gases engendered in the electric arc. I have had a rather long experience of electric lighting, and, as a chemist, I have often tested the products of the arc, and I never found nitrous acid or prussic acid when *electrodes of pure carbon were in use.* No doubt, when carbon rods contain potash, soda, or alkaline earth, prussic acid, or, perhaps, nitrous acid will be found in the arc, but not when the electrodes contain nothing else but carbon. Mr. Shoolbred has found, no doubt, nitrous acid in the arc he produced by the carbons he was then using; but it must not be, from that, taken for granted that always and under all circumstances nitrous acid is produced in the electric arc, any more than prussic acid, as Professor Dewar reported some time ago. As such reports as those might be injurious to the future of the electric light, I hope you will find room in your valuable paper for the insertion of my humble protest against statements which might prove detrimental to the best of illuminators.—Yours, &c.,

A. VASSARD,
Member of the Chemical Society of Paris, &c.,
Vassard's Carbon Electrodes Company,
39, Commercial-road, October 6th, 1879.

THE INFLUENCE OF ELECTRICITY UPON VEGETATION.

The experiments of M. Naudin in relation to this question have been recently brought before the Académie des Sciences. M. Grandeau, the director of the Station Agronomique at Nancy, announced some time ago that certain experiments upon Indian corn and tobacco showed that atmospheric electricity exerts a very favourable influence upon vegetation. M. Naudin, the director of the botanical garden at Antibes, now brings forward some facts which point to an opposite conclusion. His experiments being made upon other plants and in a different climate, he considers that the conclusions of M. Grandeau were too general. In his opinion, atmospheric electricity, like all other agents in vegetation, fulfils a useful purpose, but one which, in case of need, can be accomplished by another agency. The experiments of M. Naudin were conducted in the following manner:—

Two small portions of ground, each having 51 square decimetres of surface, and 7 metres apart, were selected in a kitchen garden fully exposed to the sun. In each of these were planted a dwarf bean, a lettuce, a tomata plant, and two seeds of herbaceous cotton plant. One portion of ground was left exposed, the other was covered by a cage of iron wire, having pointed iron rods at each corner, for the purpose of conducting to earth the atmospheric electricity. During a fortnight, the plants apparently made equal progress, but at the end of that time a difference became observable; and this difference, which was altogether to the advantage of the enclosed plants, became more and more manifest. The bean within the cage was much more forward and more fruitful than that in the open air. In regard to the lettuces, that in the open air obtained a height of 1 metre, that under the cage 1·2 metre; the total weight of that in the open air was 337 grammes, whilst the one beneath the cage was 427 grammes. The tomato in the open air was ·8 metre in height, that beneath the cage was 1 metre; in the former case the number of fruits was 37, and their weight 1,080 grammes, whilst in the latter case the number was 83, and the weight, 2,162 grammes.

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PRECIS OF A REPORT ON ELECTRIC LIGHT EXPERIMENTS.*

BY LOUIS SCHWENDLER.

Mr. Schwendler said it would be impracticable to read the "Précis of Report on Electric Light Experiments" *in extenso*, since it contained too many technicalities, which could not easily be followed if the Paper were read in the manner usual at these meetings, and that he, therefore, would prefer to give verbally a short account of his researches and the results obtained. He stated that the inquiry originated with General Strachey, who, in April, 1876, recommended to the Secretary of State that a trial of illuminating Indian railway stations by the electric light should be made. In February, 1877, Mr. Schwendler was requested to institute detailed inquiries, which led him to propose that it would be advisable to first make some more experiments before a practical trial at Indian railway stations should be attempted. The Board of Directors of the East Indian Railway Company agreed to this, and sanctioned the necessary outlay, whatever it might come to.

The experiments made at the India Office Stores, London, terminated on the 1st November, 1878. The report, however, could not be finished in time before Mr. Schwendler left for India, and he therefore prepared a précis—the Paper before the meeting to-night. After pointing out the general results obtained, and explaining in a brief manner the three principal questions at issue, viz., *economy of the electric light, practicability and efficiency of the electric light for certain illuminating purposes, and best means of distribution of the electric light*, Mr. Schwendler proceeded:—

You all have heard, no doubt, a great deal about the division of the electric light. During the last two years this question has been before the public almost permanently. This is not to be wondered at if we consider that on the solution of this problem it will ultimately depend whether the new mode of lighting becomes a successful and general rival to the illumination by gas or other combustive means. But before entering on the subject, it will be best to formulate the question definitely, to avoid any misunderstanding with respect to the answer I am about to give. The question is:—A given permanent current (C), no matter how produced, does work in a closed single circuit, of total resistance (R), of which a part (r) represents the resistance of *one* electric arc. This electric arc produces an electric light of *measured* intensity (I). Now, if we introduce, instead of *one* arc, *two* arcs of resistance r' and r'' and measured light intensities i' and i'' respectively, and suppose the current to be the same as before, or the E.M.F. and total resistance in the single circuit the same, then *à priori* we should conclude that $I = i' + i''$ for $r = r' + r''$. Experiments, however, show that this is not the case—*i.e.*, the sum of the measured intensities of *two* small lights is perceptibly smaller than the measured intensity of *one* large light; and this difference becomes larger and larger as we increase the number of lights produced by the same current—*i.e.*, by the same E.M.F. with the same total resistance in circuit. This appears at first sight an inconsistency with the known laws of *cause* and *effect*. How is it possible that the *same* current through the *same* resistance should produce more light in *one* point than in *two* points, although the total amount of work done by the given and constant current is exactly the same in *one* point as in *two* points?

That the *measured* intensity of *one* light is invariably greater than the sum of the measured intensities of n lights, is an undoubted fact proved by my own experiments very conclusively. But we may well ask, What has become of the energy which is expended and does not appear as light?

A careful analysis of all the physical facts connected with the subject will, however, show easily enough how this apparent loss of energy is to be accounted for, without reverting to far-fetched explanations, and without the necessity of making such statements as "the division of the electric light is in contradiction to dynamic principles," or "the laws of nature must be reversed" (whatever that may mean), or "new laws have to be discovered first, before a solution of this important problem could be even attempted," &c., &c., which I have read frequently in scientific or professional journals and newspapers. Statements of this kind appear very clever to the uninitiated, and they are exceedingly cheap to make; but they will invariably do an enormous amount of harm to the further progress of an important application of the resources of Nature.

It will be seen from the foregoing that I have called the light-intensity *measured* intensity. For if we produce a light by any source, it will be at once perceived that not *all* the light produced by that source can be made available for illuminating purposes. A part of the total light will be lost for the special purpose of illumination, inasmuch as only a part of the total light is in a position to act on the photometer, or, which is the same, on the retina. Hence we may say the total light produced by any means consists of two parts: the one is lost for illuminating purposes, and may be called *internal* light; the other acts on the retina, can be measured, and may be called *external* or *measured* light. For instance, of all the light produced in *one* electric arc, a considerable part is hidden by the electrodes between which the arc plays, because the electrodes have a volume, and, moreover, the positive electrode is hollowed out like a dome, and it is the highest point of that dome which contains the most intense light, which is mostly lost. How much this loss in each case will be depends on a variety of circumstances. In the first place, all other conditions being the same, that loss will increase with the thickness of the electrodes. The loss of light will further increase with a decrease of the length of the arc. By length of arc is to be understood the distance between the highest point of the hollow of the positive electrode and the apex of the negative electrode. Hence already, in the case of *one* arc, although naturally we have here the longest arc for the given current and the given electrodes, the light lost, or the *internal* light, may represent a considerable portion of the total light produced in the arc.

If we produce *two* arcs, it will be seen *at once* that the sum of the losses must be greater than the loss in *one* arc. Hence the sum of the measured intensities of two lights must also be smaller than the measured intensity of *one* light. Suppose the length of *one* arc, when a given current passes, is 3 mm., then the sum of the lengths of *two* arcs will not be 3 mm., but much less, in order to have the same current passing through the *two* arcs as passed before through *one*. From this it follows that the loss of light must increase rapidly with the number of lights, and, moreover, that soon a limit for the possible practical division of the electric light is reached, leaving out the question of economy altogether.

This constitutes one of the reasons why the division of the electric light becomes less and less economical with increase of the number of lights, and that soon a practical limit will be reached for the division.

To express this result more definitely, we may say:—

The consumption of power per unit of *measured* or *external* light is a function increasing with the number of lights produced by a given current in a single circuit—supposing, of course, always that the sum of resistances of the n arcs is equal to the resistance of *one* arc, and that the other resistance in the circuit, in which no light is produced, has remained constant throughout.

If we had a material infinitely conducting, of infinite strength, and with a melting point at least as high as that of carbon, then surely the division of the light would be perfectly economical up to any limit, inasmuch as we might then use linear electrodes.

In practice we can only try to approach this limit. Up to the present time there appears to be no better material for electrodes than carbon, either natural or artificial. But this is no reason why an effort should not be made to try to find a material for electrodes more accommodating to the division of the electric light than even carbon. The above, limited strength, limited electric conductivity, and limited melting point of the material of electrodes, constitute only *one* of the difficulties which stand in the way of an unlimited economical division of the electric light.

A second cause is, for instance, the fact that in each arc an E.M.F. is established opposite to the original E.M.F., and by no means to be neglected against it. This secondary E.M.F. established in each arc appears to be a function of the current which passes the arc, most likely proportional to that current. Hence, if for a given current passing *one* arc this secondary E.M.F. be e, then the same current through n arcs, successively connected, would produce an E.M.F. equal to $n\,e$. This secondary E.M.F. $n\,e$ is to be subtracted from the original E.M.F.; and, internal resistance of the original E.M.F. plus resistance of leading wires having remained constant, we necessarily have to decrease the total resistance of the n arcs in order to work with the same current as before. This merely means a decrease of the total length of the n arcs, or, which is the same, an increase of internal light, or decrease of the *measured* or *external* light. A parallel connection of the n arcs with reference to the poles of the given original E.M.F. would certainly produce only *one* secondary E.M.F. instead of n; and for this reason it might be better to use the parallel circuit for the division of the electric light. But there are other very important objections to this solution. In the first place, as can be easily shown, the variation of one arc has a far greater influence on the variation of the others in parallel, than in successive circuit. Further, the length of each arc must be made very much smaller in parallel circuit than in consecutive circuit.

Another reason against an unlimited economical division of the electric light is constituted by the practical necessity that lamps, of whatever construction they may be, have a resistance

* Read before the Asiatic Society, 5th March, 1879.

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inherent to their nature in addition to the resistance of the arc. For instance, in an ordinary lamp with an electro-magnet, the resistance of the lamp consists of the resistance of the electro-magnet plus the resistance of the two eletrodes when metallically closed. This resistance, although small, is by no means *nil*, and cannot be neglected against the resistance of the arc, especially when strong currents are used. In other words, when producing the electric light in *n* points instead of one point, we are unable to practically fulfil the condition, that the sum of the resistances of the *n* arcs is equal to the resistance of *one* arc, to have the same current—*i.e.*, the former must be made smaller than the latter, on account of practical construction reasons.

We may, therefore, sum up as follows:—*The economical solution of the division of the electric light is theoretically quite possible, but practically difficult to obtain.* The division can never become unlimited; but ingenious inventors may nevertheless *solve the problem practically.*

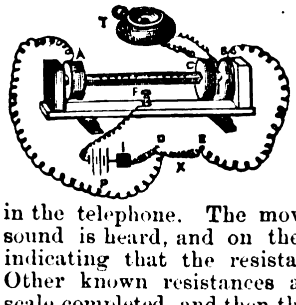
The attempt by inventors to solve the question is, therefore, perfectly legitimate. If their attempt cannot lead to a perfect solution, they may nevertheless do so approximately, and by it tend towards real progress in illumination, inasmuch as by their attempts the electric light may probably become more and more a successful general rival to gas, which at present the electric light certainly is not.

Before I conclude I must briefly avert to a Paper on the Electric Light by Mr. W. H. Preece, published in the *Philosophical Magazine* for January, 1879, in which the author believes that he has demonstrated from dynamical considerations that the division of the electric light is impossible. This it certainly is under the conditions introduced by Mr. Preece, viz., that the resistance of each voltaic arc, or each incandescent wire, is maintained *constant*. But it is unfair to the electric light to introduce this condition, especially as it does not all represent the question at issue.

When a number of lights are connected in series, the resistance of each must be diminished, and when a number of lights are joined parallel, the resistance of each must be increased in proportion to their number, so as to maintain the total external resistance constant. If Mr. Preece will introduce this condition into his equation, he will find that theoretically the division of the electric light is quite possible—*i.e.*, that, theoretically, however the lights be arranged, the unit of light will always be produced by the same expenditure of energy. Inventors should not, therefore, be downhearted. On the other hand, investors in gas need not hasten to get rid of their shares; for there are many questions involving practical difficulties which still remain to be solved; but, at the same time, gas companies should be aware that they have a formidable rival in the field, and bestir themselves to maintain the lead they hold by improving their own means of illumination and extending its application.

MEASURING RESISTANCES.

The second plan described by M. Hospitalier, referred to in our last issue, is a null method of measurement, as was the one previously described. In this method, in which he uses a modified form of Hughes's audiometer, two similar coils, A and B, are connected in a devised circuit with the battery the current of which passes through a vibrating contact. As in the first case, a coil of fine wire C is placed between the coils A and B, and connected to the telephone. This coil slides along a graduated bar, so that its exact position may be easily determined. If, on introducing an unappreciable resistance between the binding screws D and E, the current in A has the same intensity as in B, the actions of A and B upon C are equal and contrary, so that no sound is heard in the telephone. If a resistance be introduced between C and D, say one ohm, then the actions of A and B upon C are no longer equal, and a sound is heard in the telephone. The movable coil B is now adjusted till no sound is heard, and on the graduated scale a mark 1 is made, indicating that the resistance between D and E is one ohm. Other known resistances are successively introduced and the scale completed, and then the unknown resistance inserted may at once be obtained by reading the scale at the point where sound in the telephone ceases. It is necessary that the battery used should be powerful enough to enable the feeblest sound in the telephone to be heard. The author of this method believes that it will be of great service for measuring the resistances of conductors, of electro-magnets, and telephone coils, because of its extreme simplicity.



CONTACT THEORY OF VOLTAIC ACTION.

Parts I and II.

By W. E. Ayrton and John Perry, Professors in the Imperial College of Engineering, Tokio, Japan.

Part II. (continued from page 240).

We might expect that in those cases in which melted metals have a considerable electromotive force of contact they would combine to form alloys with great rapidity, on account of their great conductivity and sufficient mobility to continue chemical combination. The great conductivity of mercury, and its mobility and the mobility of the compounds which it forms with other metals, enables it to enter rapidly into combination with those metals with which it has a great electromotive force of contact. And it is probable that the electromotive force of contact of mercury with iron or with steel is exceedingly small, or that the amalgam is a solid except at very high temperatures. Cold glass is acted on by hydrofluoric acid, and this is possible on account of the great electromotive force, and on account of the silicon tetrafluoride formed by the combination being volatile, and, therefore, possessing great mobility. Hitherto chemists have only employed the two ideas of chemical affinity and the amount of chemical action, but we have shown that these ideas are simplified when regarded as electromotive force of contact and currents of electricity. To connect the two ideas we have a third, viz., *resistance*, and the electrical law of Ohm becomes the chemical law—*the quantity of chemical action in unit time equals the sum of a great number of terms, each of which is an electromotive force divided by a resistance.*

Gutta Percha.

The metallic plates of the last experiment were carefully cleaned, and the paraffin wax replaced by a sheet of gutta percha, previously scraped, washed with soap and water, ordinary water, alcohol, sodium carbonate, and hot distilled water, and thoroughly dried. The upper plate A was of clean zinc as before. Our experiments on the conductivity of gutta percha, described further on, show that it increases with the temperature, not only at the low temperature at which it has hitherto been examined, but also after it has become plastic at higher temperatures.

At the lowest temperature at which we examined the arrangement there was a decided charging of the plates, but it was so slow that we must regard the measurement of the minimum electromotive force 0·23 volt as being too small, for a careful examination of the defects of the electrometer showed that under these circumstances the measurement *might* be too small. At higher temperatures the maximum charge was established with much greater rapidity.

On each day, some time after the commencement of the experiment for that day, the electromotive force, having remained constant for some time, suddenly increased, and then remained nearly constant at its higher value. This seemed at first to be due to the plates having been short-circuited for intervals of four minutes or more, but we afterwards found that it occurred when the plates were only short-circuited for a few seconds to get to zero. Also, it did not seem to occur at a particular temperature. On one occasion the sudden rise happened at about 35°C., and on another at about 72°C. On the first of these days the mean low electromotive force was 0·584 volt, and the mean high 0·763 volt, the very lowest and very highest being 0·54 and 0·86 volt. On the second day the mean low was 0·534 volt and the mean high 0·773 volt, the lowest and highest being 0·529 and 0·789 volt. We are sure, when these measurements were made, that the conductivity of the gutta percha was sufficiently great to eliminate any effects due to the minute defects of the electrometer.

As in the case of paraffin, the conductivity calculated from the time readings, whilst the zinc and copper plates were establishing their charge, is greater than the conductivity measured independently by two copper plates charged with a battery for about five minutes, and then kept insulated.

Ebonite.

Between the zinc and copper plates was placed an ebonite sheet, having an average thickness of 0·35 millim. It was chemically clean, and there was no surface conduction at even low temperatures. We found, as in the previous cases, that there was evidence of an electromotive force, but the charging proceeded very slowly until about 36°C., when the conductivity had greatly increased. During thirty-five minutes the temperature steadily increased to 74°C., and, as there was no indication of a maximum charge, we let it increase without short-circuiting during this thirty-five minutes, at the end of which time the deflection indicated an electromotive force of 3 volts. After short-circuiting

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the charge again established itself, but it did not increase as rapidly as it had done at first at the lower temperature, although from our independent experiments we know that the conductivity is greater at higher temperatures. Precautions have been taken to avoid any sliding of the ebonite plates during the experiments, for certain preliminary observations showed that such sliding would produce charges of electricity which would mask mere voltaic results. From the mathematical expressions for conductivity and from our experimental determinations of the conductivity at any given temperature, we endeavoured, by calculation, to discover whether the first set of time readings indicated an approach to a maximum; but we obtained inconsistent results, the maximum electromotive force thus calculated varying from 3 to 12 volts. After the experiments the zinc plate was found to be only slightly dulled in its polish and not coloured, neither did the copper plate appear much changed in appearance, but a lead weight which had been laid on the zinc to keep it in close contact with the ebonite was found to be quite red.

It is evident, therefore, that this arrangement had nothing in common with an ordinary simple cell, the great charging of the plates being due to a decomposition of the ebonite by heat.

India Rubber.

In November, 1875, we endeavoured to find the electromotive force of a simple cell formed by placing a sheet of india rubber containing sulphur between zinc and copper plates, and we then obtained results analogous to those which have just been described for ebonite. During the present investigation we expected to obtain the same results, since we used the piece of india rubber which had previously been employed. Contrary to our expectations, however, there appeared to be no further decomposition of the india rubber by heat, and results analogous to those previously obtained with the paraffin wax were met with. Probably, therefore, all the sulphur that could easily be liberated had been expelled by the previous heating. At about 90°C. the conductivity was sufficient to enable us to measure, with some accuracy, the electromotive force, which we found to be 0·168 volt; but, somewhat as in the case of the gutta percha, between 90° and 100°C. the electromotive force increased to 0·356 volt. This increase did not appear to be as sudden as in the case of gutta percha, but, as before, the electromotive force was fairly constant on each side of this place of changing.

Shell-lac.

An extremely thin sheet of shell-lac was placed between sheets of zinc and copper, as in the preceding experiments. At low temperatures there was evidently an electromotive force, which, at 28°C., we were able to measure, as the conductivity was sufficiently great. From this temperature upwards there was practically no change. In fact, the electromotive force was constant and equal to 1·12 volts. At temperatures higher than 65°C., the arrangement established its charge after short-circuiting with the rapidity of an ordinary liquid voltaic cell.

Resistances of the above Electrolytes.

It has been usual for telegraph engineers to measure the resistance of gutta percha, india rubber, &c., after a current has been passing through the material for one or for not more than three minutes. Now, although this may be a very valuable test of a telegraph cable, since the amount of apparent loss, through want of insulation during the first small period of charge, is one of the elements affecting the received current, still since this loss is due to two causes, soaking in and true conductivity, and since the former is at first so very great compared with the latter, the real resistance can only be ascertained after the current has been on for a length of time. The practical time of charging necessary to enable the current to be a true measure of the conductivity seems to be less at higher temperatures, and in our experiments we have endeavoured to approximate to the elimination of soaking in.

Paraffin Wax.

In November, 1875, we made a great number of time observations of the difference of potentials of two copper plates immersed in paraffin wax, and kept asunder by three small pieces of glass, 0·191 centim. thick, the upper plate having been originally charged to a certain potential, and the lower plate kept in connection with the earth. We found that the conductivity increased with temperature, the increase being very rapid near the melting point, at which place, as we used no auxiliary condenser, the rate of loss of charge was very high. To measure the conductivity of melted paraffin we employed a very delicate reflecting astatic galvanometer of 20,000 ohms resistance; one Daniell's cell, through a resistance of 120 megohms, gave a deflection of 131·3 divisions on an ordinary scale, at about a metre distance. The current from a battery having a measured electromotive force forty-seven times that of our standard Daniell passed through the paraffin and the galvanometer. Full precautions were taken to avoid all leakage except through the paraffin, the deflection of the galvanometer needle due to instrumental leakage alone being quite imperceptible. The thermometers did not indicate truly the temperature of the paraffin, being too high when the apparatus was heating, and too low when it was cooling; but as the cooling was very slow, the results which are given in following table, obtained during cooling, and which, when plotted, give the curve J K (Fig. 1),* may be regarded as being fairly correct, for the observations seem to be all very consistent with one another.

The area of the upper plate was 56·25 square centims., and hence if x is the specific resistance in megohms per cub. centim. of paraffin, and if D is the deflection on the galvanometer scale,

$$\text{Log}\, x = 8\cdot 3374 - \log \text{D}.$$

Temperature. Degrees.	D.	x in megohms.
90·6 C.	167·9	$1\cdot 295 \times 10^6$
96·8	229·9	$0\cdot 946 \times 10^6$
91·0	191·6	$1\cdot 135 \times 10^6$
84·0	151·9	$1\cdot 432 \times 10^6$
80·0	132·3	$1\cdot 644 \times 10^6$
76·0	115·9	$1\cdot 876 \times 10^6$
70·2	94·5	$2\cdot 301 \times 10^6$
65·1	78·0	$2\cdot 788 \times 10^6$
60·0	64·0	$3\cdot 398 \times 10^6$
55·2	55·0	$3\cdot 954 \times 10^6$
50·0	43·0	$5\cdot 058 \times 10^6$

In the above table we have given only every fifth observation. The curve M L has for co-ordinates the temperature and galvanometer deflection as the temperature increased. The points M, L, K, J correspond respectively with the temperatures 90°·6, 94°·7, 93°·1, 48°C. In this and in the other curves we have employed such scales as have seemed to us most convenient. In every case we give the true co-ordinates of some points, and from these the scale may be easily determined. Ordinates measured parallel to the line O X represent temperature, the temperature increasing towards O.

We were unable to obtain galvanometer and electrometer tests at the same temperature, since the galvanometer did not give deflections at low temperatures; and as we had not at this time designed the time roller described above, and as no auxiliary condenser was used with the electrometer, the loss of charge was too rapid at high temperatures to make accurate time observations.

The oil bath used in November being small and otherwise inconvenient, we proceeded in May of this year with the investigation, using the apparatus described above. At low temperatures time observations of loss of charge were taken on a fixed scale. Near the melting point time observations were taken on the roller in motion, and at higher temperatures, one terminal of an auxiliary condenser of one-third microfarad capacity and excellent insulation was attached to the plate A, the other terminal of the condenser being connected with B. Four Daniell's cells were used to charge A.

At 20°·9 C., the temperature of the room, A, experienced no loss of charge in ten minutes whether or not the condenser was attached.

A number of preliminary experiments showed as before that there was a great increase of conductivity at melting. For instance, on May 15th, when the temperature was rising, the paraffin appeared to be solid at 46°C., and it appeared to be liquid at 52°C., and between these two temperatures we obtained the following results, t being measured in minutes always.

Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
46· 5 C.	0·00114	34190×10^6
48· 3	0·00168	26480×10^6
50· 0	0·00225	17320×10^6
50· 4	0·00607	6421×10^6
50· 8	0·01600	2436×10^6
51·15	0·03970	$998\cdot 2 \times 10^6$
51· 2	0·07000	$556\cdot 8 \times 10^6$
51· 3	0·30000	$129\cdot 9 \times 10^6$
51·35	1·26000	$30\cdot 93 \times 10^6$
Afterwards when cooling.		
48· 4	0·0689	$565\cdot 7 \times 10^6$
48· 2	0·0308	1266×10^6
45· 1	0·0133	2930×10^6

These results cannot be compared directly with those previously obtained with the galvanometer, because in the former case the paraffin was cooling from a high temperature, 90°C.,

* This, together with Fig. 2, will be given in our next issue.—Ed. E.

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whereas in this case the temperature was only raised to 51°, and it is well known that when paraffin is cooled from a high temperature, it will remain liquid at temperatures at which it would be solid were it being gradually heated from a low temperature.

(TO BE CONTINUED.)

LITERATURE.

Catalogue of Electrical Apparatus. Parts I. and II. By E. PATERSON.

This is a catalogue of a kind that is almost unique in England, but is well known in America and in France. In fact, it is not only a catalogue, but at the same time a handbook, containing a large amount of carefully-compiled information. The various apparatus is illustrated. Among the information we would specially direct attention to the remarks on "Electric Bells and their Construction." Ordinary text-books do not deal with such subjects as this, but then ordinary text-books deal more with the theoretical than the practical, while such a work as this is nothing if not practical. The *raison d'être* of the work is given in the preface to Part II., where we read:—

"There is a large and growing class of practical bell-fitters, builders, engineers, and others, who have not the means of acquiring a professional training in these matters, and are deterred by their ignorance of them from adopting these improved systems of signalling, or, where they adopt them, have to place the work in the hands of a professional electrician, when it might just as well be done by themselves. It is my aim, as briefly as possible, to supply just so much information as is necessary to enable such with confidence to undertake the work and prevent failures, which, in the great majority of cases, are only explainable on the supposition of gross ignorance."

The idea thus expressed has been well carried out, and we incline to the opinion that any mechanic of ordinary abilities who desired to fix up a set of electric bells would have little or no difficulty in the work after he had carefully studied the information here provided for him.

RECENT PATENTS.

229. TELEPHONES, *W. R. Lake.—Dated 20th January*, 1879.—(*A communication.*) 6*d.*

A metal ring holds the mechanism to the cover of a box, and on the inner surface of this ring is a narrow ledge on which the diaphragm is placed. The centre of the ring and diaphragm is opposite an orifice, in the cover through which the sounds enter. On the other side of the diaphragm and at its centre is placed one electrode consisting of a metal bar, one end of which rests against the diaphragm, and the other is brought nearly to a point and is in contact with the other electrode. The latter is formed on a weighted spring supported on an adjusting lever by which the tension is regulated.

245. APPARATUS EMPLOYED IN ELECTRIC LIGHTING, *R. C. A. Crompton and P. W. Willans.—Dated 21st January*, 1879.—(*Not proceeded with.*) 2*d.*

The electrode consists of a disc rotated by the electric current or by clockwork, and is supported so as to allow its axis to be moved towards the light as it is consumed. A roller in contact with the electrode is rotated by a spring or weight, and moves towards the centre of the electrode, the two being so connected that both move the one towards the other.

412. COMPOUND MICROPHONES, *L. J. Crossley, Dated 1st February*, 1879. 6*d.*

A microphone is mounted on a parchment diaphragm and connected with a battery and induction coil, so that any variations in the microphone caused by sound waves effects a corresponding reaction in the strength of the current of electricity flowing through the microphone and induction coil. The variation also causes a variation in the current induced in the induction coil, which, being connected to a telegraph line, causes corresponding currents to flow through the telegraph or electrical wires, and by attaching a telephone to the distant end of these wires causes, by the increase of the intensity of the sound produced, the message conveyed to be faithfully, plainly, and distinctly heard and recorded.

416. ELECTRIC LAMPS, *J. D. F. Andrews.—Dated 1st February*, 1879. (*Not proceeded with.*) 2*d.*

Two plates of carbon are placed face to face at a little distance apart, and are connected to the electrical circuit, the voltaic arc presenting itself at some point of their peripheries, and as the carbons are consumed the arc travels round the periphery, and inwards towards the centre of the plates.

427. ELECTRIC LAMPS, *C. Dubos.—Dated 3rd February*, 1879. 4*d.*

The carbon rods are of semicircular form, and two of them are mounted in a lamp, so that one point of each is towards each other, the other point being held in a socket at the end of a radius, so that the two carbons nearly complete a circle round a centre about which the socket radii are free to move. On the axis of each radius are fixed pulleys, round which cords pass, one cord in each case being connected to a lever acted on by an adjustable weight, which tends to force the points together. The other cord is connected to a soft iron core, free to move within a coil of wire that forms part of the electrical circuit. The core being attracted into the coils acts on the radii, so as to separate the points.

508. SHADES OR LANTERNS FOR ELECTRIC LIGHTS, &c., *H. V. Weyde.—Dated 8th February*, 1879. 6*d.*

An armillary arrangement of reflectors surrounds the lantern in parallel zones above and below the luminous focus. These annular reflectors are in two sets separated by an equatorial band or prism, and they are slightly concave, the upper set on their lower surface and the lower set on their upper surface, and they are so formed and spaced as to intercept the whole of the upwardly and downwardly projected rays and divert them horizontally in all directions.

513. ELECTRO DYNAMIC APPARATUS, *J. Imray.—Dated 10th February*, 1879.—(*A communication.*)—(*Not proceeded with.*) 2*d.*

This relates to means of producing motive power by bringing a number of electro-magnets into successive action on a moving armature, so that as the force of each on the armature decreases owing to distance the force of the next in order shall act upon it.

523. ELECTRIC LIGHT, *E. T. and W. R. Bousfield.—Dated 10th February*, 1879. 6*d.*

A rotating armature is used made in the form of a drum, and composed of longitudinal sections secured in place by end plates, which are mounted on the armature spindle. These sections consist of segmental armatures, the core of which is preferably —— shaped in cross section, the flanges being set radially, and the induction coils laid longitudinally round the core. Or the sectional armatures may be made by coiling insulated wires on flat bars lengthwise in such manner that when placed together the periphery of the drum would present to the exciting magnets an unbroken surface of copper coils; the cores would, as in the former case, be connected magnetically. The second part relates to holding and feeding, say, the positive carbon in an electric lamp. The carbon is held in a grooved holder, through which, when no current is passing, it slides freely until it touches the negative electrode. When the current passes the carbon is gripped tightly in its holder.

529. ELECTRO-PLATING, *T. H. Blake.—Dated 11th February*, 1879. (*Not proceeded with.*) 2*d.*

Eighty ounces of commercial cyanide of potassium are dissolved in 20 gallons of water, and 100oz. by measure of strong liquid ammonia of the specific gravity of 880 is then added; next, 10oz. of nitrate of silver and 3oz. carbonate of potassa are added, the whole being allowed to stand, and then carefully decanted, when it is ready for use, with the addition of a large anode of tin and a small anode of silver. The article to be plated is immersed in the solution, and connected with the negative pole of the battery, the two anodes of metal being connected to the positive pole.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES OCT. 8.		BUSINESS DONE WEEK ENDING OCT. 8. Highest.	Lowest.
Anglo-American Ordinary	58,	¼	58¾	56¾
Do. "B"	84½,	5	85	84
Do. "A"	33¾,	4¼	34¼	31¾
Brazilian	6 15-16,	7 1-16	7⅛	6⅞
Cuba	7¾,	8¼	8	8
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11¼,	¾	11¾	11¼
Direct United States	11⅛,	⅝	11⅜	11⅛
Eastern	7 15-16,	8 1-16	8 1-16	7⅞
Do. Six per Cent. Debenture	105,	108	106	106
Do. Five per Cent. do	102,	104	103	102½
Do. Six per Cent. Preference	11⅞,	12⅛	—	—
Eastern Extension	8,	⅛	8⅛	7 15-16
Do. Six per Cent. Deb.	105,	108	—	—
German Union	7¼,	¾	7¾	7½
Globe Telegraph and Trust	5½,	¾	5¾	5
Do. Six per Cent. Preference	11½,	⅞	11⅞	11⅞
Great Northern	8⅜,	⅝	8⅝	8⅜
Indo-European	21,	22	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9,	10	—	—
Submarine	225,	230	—	—
West India and Panama	1¼,	½	1 7-16	1¼
Do. Six per Cent. Preference	7¼,	¾	7¾	7½
Western and Brazilian	3,	½	3½	3
West. Union Seven per Ct. 1st Mt.	120,	125	—	—
Do. Six per Cent. Sterling	105,	107	105½	105½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1879.

COMPANIES.	Sept. 1879.	Sept. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,463	537	—
Direct Spanish Telegraph Company	1,121	1,048	73	—
Direct United States Telegraph Company	—	—	—	—
Eastern Telegraph Company	39,369	38,169	1,200	—
Eastern Extension Telegraph Company	26,980	22,151	4,829	—
Great Northern Telegraph Company	18,775	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	1,200	—	—	—

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NOTES.

India Rubber.—Prices are still ruling upward. Para is being sold at 3s. 2d. per pound.

Eastern Extension Company.—The ordinary meeting of this Company will be held at the Cannon-street Hotel on Wednesday, October 22.

Reuter's Telegram Company.—The directors of Reuter's Telegram Company (Limited) have declared an interim dividend at the rate of 5 per cent. per annum, free of income-tax, for the half year ending the 30th June last.

Globe Telegraph and Trust Company.—The Globe Telegraph and Trust Company (Limited) will pay, on and after the 18th inst., the interim dividends for the quarter then ending of 3s. per share on the preference shares, being at the rate of 6 per cent. per annum, and 2s. per share on the ordinary shares, being at the rate of 4 per cent. per annum, both free of income-tax.

The Telephone.—The Pittsburgh Southern Railroad, extending from Pittsburgh to Washington, Pa., a distance of over 36 miles, has discarded the telegraph instruments for the telephone in the transaction of business, including the running of trains. It is said a whisper in Washington can be heard in Pittsburgh. Several western railroads have also resorted to the use of the telephone instead of telegraphic instruments.

The Electric Light at the Paris Opera House.—The French Government have decided to introduce the electric light into the Opera House as an experiment. The lights will be placed at the top of each of the chandeliers, with the exception of two, where gas will for the present continue to be burned. At one end of the *foyer* there will be four Jablochkoff lights, and at the other four Werdermann lights.

Brazilian Submarine Telegraphs.—The accounts of the Brazilian Submarine Telegraph Company (Limited), show a profit for the year ended 30th June sufficient to enable the directors to recommend a final dividend of 2s. 6d. per share, making, with previous distributions, 5 per cent. per annum, and carrying £50,000 to the reserve fund, increasing that fund to £227,437 8s. The dividend will be payable on the 29th inst.

The Electric Light at the British Museum.—It is the intention of the trustees of this institution to use the electric light in the reading room during the winter months in order to extend the hours for readers, and to illumine the room in foggy weather. The system will be tried of a few lamps hung high above the floor level, and a diffusion of the light by reflectors. The arrangements will be directed by Messrs. Siemens Brothers.

Trade.—The export of telegraph wire and telegraph apparatus has been less during the past month than in the corresponding month of 1878. The value of the exports in September, 1879, is given as £64,645, while that of September, 1878, was £116,825. The value for the nine months of 1879 is, however, greater than for that period in 1878. Thus in 1878 the value from January to September was £676,945; in the corresponding period 1879 it was £1,498,617.

Meteoric Gold.—The remarkable specimen of meteoric iron, resembling steel, picked up in the Mohau desert and carried to Fort Yuma, a short time ago, is thus described: "It weighs about a pound, and carries free gold, of which nearly a dollar appears on the surface. It is not magnetic, and has successfully resisted simple and compound baths of acid. In this respect it resembles specular iron, but in no other. One of its surfaces shows a fracture that reveals a crystalline structure, the colour of which is steel grey, tinged with yellow. It has defied the best cold chisels in the blacksmith shop, and has not broken or chipped under heavy blows. If its composition can be imitated it will produce the hardest and toughest alloy known."—*Galveston (Texas) News.*

The Electric Light in Burmah.—The *Times of India* says:—"An extensive business transaction has just been concluded between the Indian Electric Light Company and the King of Burmah. Attracted by the experiments which have been made in this country with the electric light, King Theebaw sent an agent over to Calcutta to purchase the largest portion of the company's machines and plant in Calcutta and Bombay, including the apparatus that was lately employed in illuminating the Hooghly Bridge. The Burmese agent paid down 80,000rs. in hard cash, and we are informed that the entire cost of the lights—40 of Jablochkoff's and eight of the regulator system—and fixing them in the Royal palace and gardens at Mandalay will be not less than 100,000rs. Evidently the treasury of His Majesty is in a healthy condition."

The Electric Light in the German Army and Navy.—The "Year Book for the German Army and Marine" states that the electric light has been employed for military and naval purposes—among others for lighting up the ground lying in front of a besieged fortress, for the illumination of ships at sea, and notably for carrying on work under water. A transparent bell with an electric lamp has been immersed to a depth of 60 mètres, while a magneto-electric machine placed at a distance of 100 mètres has been able to maintain a strong unbroken current, so that a brilliant light was maintained for a long time. The same authority states that experiments are now in course of being carried out for the purpose of testing how far the electric light can be usefully employed in marine warfare, and especially as a defence against torpedo attacks.

The Electric Light on Waterloo Bridge.—On the 10th inst., shortly before seven o'clock, a large number of persons assembled on the Victoria Embankment and Waterloo Bridge in order to witness the illumination of the bridge with the electric light. Some time ago the Metropolitan Board of Works decided to test the effect of the electric light on one of the metropolitan bridges, and the above bridge was selected for that purpose. A number of workmen were engaged in constructing tubes to carry the wires from the Middlesex side of the river, and the entire work is now completed. There are five electric lights on the western side and four on the eastern side, and one of a larger dimension is placed in the centre of the road on the Strand side. Several members of the Board of Works, as well as a number of gentlemen interested in the

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better illumination of the streets of London, were present. At a given signal the whole line of the Victoria Embankment as well as Waterloo Bridge was in a blaze of light, and the effect was grand in the extreme, and appeared to give general satisfaction to all connected with the experiment.

Continuous Spectrum of the Electric Spark.—If an electric spark is passed through a liquid instead of a gas, a bright continuous spectrum is obtained in place of a line spectrum. This spectrum, in the case of water and of olive oil, is characterised by its large number of blue rays, and its want of dark red rays. With other liquids, as bitter almond oil, glycerol, alcohol, and milk, differences in the dispersion of the entire spectrum and of the single colours are obtained, as well as in the intensity of the latter. The most probable explanation of this phenomenon is that the particles separated from the copper electrodes become of a white-hot redness, even in presence of water or another liquid, whilst the constituents of the air do not become so heated. Hence the spectrum loses the line character, and the continuous spectrum of the white-hot metallic particles is all that is visible.—*Journal Chem. Society.*

An Improved Lamp.—An improved lamp for the electric light has been patented by Messrs. Mori and Griffin, electricians, of Leeds, where it was exhibited a few days since in St. Luke's Schools, Beeston Hill. The lamp consists of a slate base, to which is attached the electro-magnet. In the top part are fitted the carbon-holders, supported on a drum containing a coiled spring. These carry eight pairs of carbons, fitted in parallels similar to the Jablochkoff candle, but without the insulation. Before the machine is started the carbons meet at their extreme ends, but immediately the current is generated it passes round the electro-magnet, over the south pole of which is an iron armature pivoted and attached to a small lever holding one of the carbons. When the iron armature is attracted the carbons are separated, and the arc of the first pair is formed. When these are burnt down the current is automatically shunted to the second pair, and so on until all are consumed; and, as each pair lasts about two hours, the lamp will continue to burn without interruption for 16 hours.

Use of Electricity in the Russian Navy.—We are informed that the Russian Minister of Marine has issued the following Circular, No. 82, Sept. 20, in regard to the control of electric lights on board Russian men-of-war:—1. The management on board ship of electric lights in their technical relation should be in the hands of the mining officers, in respect to their storage, &c., they should be under the control of the artillery department. 2. Every morning at 8 o'clock and after every time the dynamo-electric machines have been in use, the officer charged with the duty of looking after the electric lights must report the condition of the machines to the commander of the ship. 3. The working of the dynamo-electric machines shall fall to the charge of the mining officers, of whom one is to act as manager and another as his lieutenant. 4. The number of managing officers and lieutenants having charge of electric lights on board vessels of the Russian fleet is to be reported by the commanders, or by the commanders of ports, to the Inspecting Department. 5. Each mining officer appointed to a ship to look after the dynamo-electric machines is to be furnished with instructions and rules in regard to the management of the machines. 6. When the machines are placed in store, the managing officer and his lieutenant are to report to the storekeeper full particulars of their constituted parts, and also to note defects or omissions.

The War of the Telephones.—One of the most interesting patent litigations ever witnessed in this country is now imminent, growing out of the conflicting claims of rival inventors and patentees to the ownership of the telephone. Already nearly a hundred patents embodying supposed improvements in telephones have been issued, and more than a dozen interference suits are now pending before the Patent Office, brought in the names of as many patentees. The general public knows only of the business rivalry between the Bell Telephone Company on the one hand, and the Western Union Company owning the Edison patents on the other; but before the courts and the Patent Office the controversy takes a character entirely different. The merits of the case are very difficult to reach, and seem not to be fully understood even by experts in electricity or patent law. So many fine points in electrical science and in patent law—the most evasive and crooked of all branches of jurisprudence—enter into the matter that one becomes involved from the outset in a labyrinth of technicalities so dense that a just and intelligible solution seems to be an impossibility. The interference cases are set for a hearing some time next February, and the time meanwhile is being taken advantage of by the counsel to take testimony bearing upon the cases. Stripped of side issues, the immediate controversy appears to be narrowed down to the question of priority in the application of the principle of the undulatory current to the transmission of spoken words. Several years before the issuance of the first American telephonic patent, a German named Reis experimented in telephones, and is said to have succeeded in transmitting musical tones and vowel sounds by wire. Reis published an account of his experiments, with plans, an examination of which in the light of to-day makes one marvel that success should have eluded him. He made use of the same diaphragm which forms a part of all successful telephonic systems. In July of 1875, Elisha Gray, of Chicago, obtained a patent upon a system of transmitting musical sounds, which it was thought at the time would form the basis of a system of multiplex telegraphy. Each note in the scale was to be made the medium of communication between different points. The principle is said to be theoretically perfect. Gray's patent was reissued on the 28th of January, 1879, and forms the foundation of the counter claim of the Western Union against the Bell Telephone Company. Professor Bell's patent, the application for which was filed on the 14th of February, 1876, is based upon the employment of undulatory currents of electricity. The electrical current is never absolutely broken, but effects are produced by a variation in the strength of the current put upon the wire. This principle is a necessary part of every successful telephonic system, and by its means every variation in the volume of the human voice may be made to produce corresponding variations in the magnetic effects transmitted from point to point by telephone. Professor Bell made no claim to the discovery of the undulatory current principle, but merely to its application in the manner set forth in his application. The claim of the Western Union is that the principle of the undulatory current was covered in the Gray patent. The settlement of this question will probably be only the first in the contest, however, which involves many other points.—*Iron Age.*

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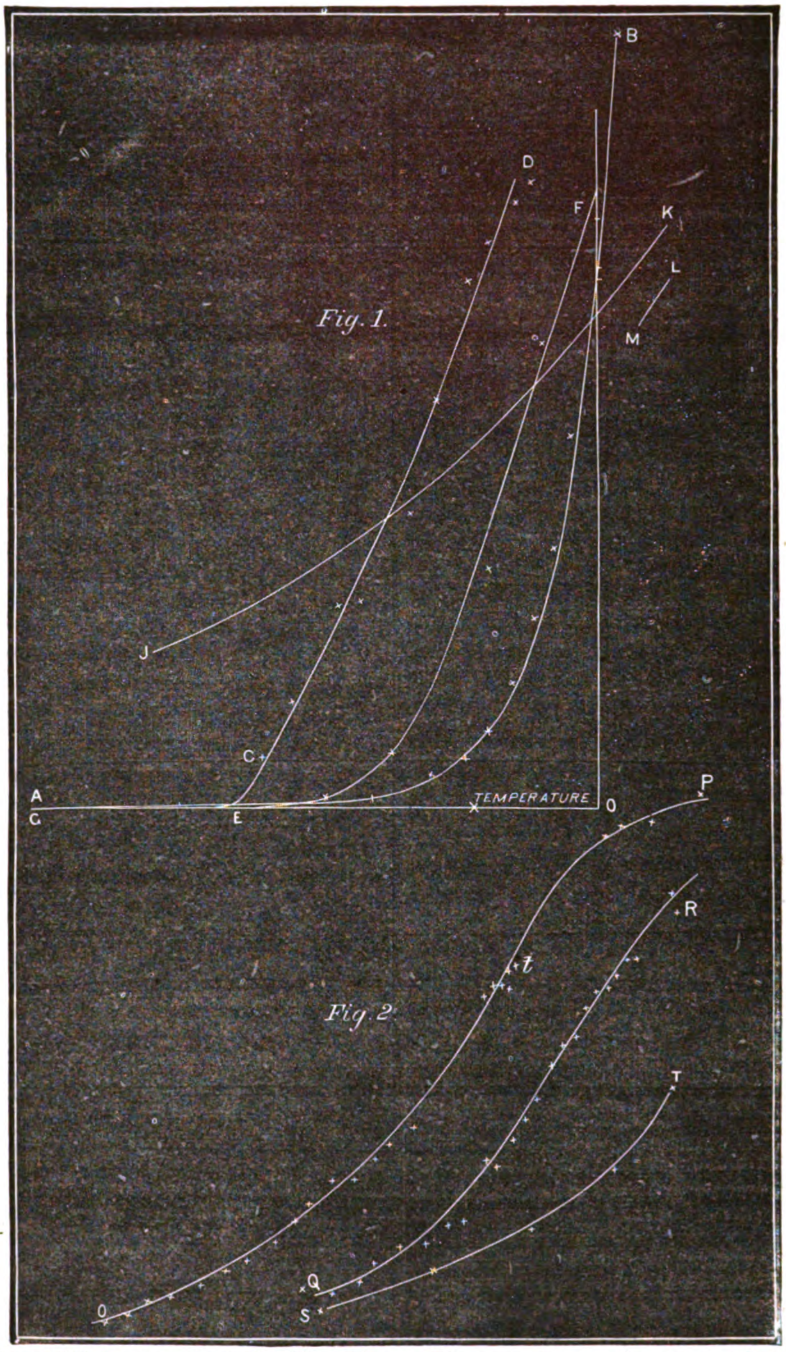
CONTACT THEORY OF VOLTAIC ACTION.

PARTS I AND II.

By W. E. AYRTON and JOHN PERRY, Professors in the Imperial College of Engineering, Tokio, Japan.

PART II. (CONCLUDED FROM PAGE 252).

Curve A B, May 16th, gives the relative conductivities when the paraffin was rising from 54°C. to 56°C. At 54° the paraffin seemed to be solid, and it did not appear to be melted at its upper surface, even for some time afterwards, when the thermometers indicated 60°C. But at 56°C. it was covered with white eruptions. With the condenser, May 16th, we obtained the following tests. As we did not employ the roller, the conductivities deduced from detached readings are often inconsistent, and yet each of these conductivities was deduced from a number of observations, in some cases from twenty. This shows the difficulty of making eye observations, for when using the time roller and tracing on it with a pencil the path of the image of the cross fibres, no such inconsistencees were met with.



Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
60·2 C.	0·1175	4·482 × 10

The paraffin was quite liquid over the upper plate.

62	0·0205	$2·569 \times 10^6$
64·5	0·0222	$2·372 \times 10^6$
68·5	0·0261	$2·018 \times 10^6$
72·5	0·0312	$1·689 \times 10^6$
76·6	0·0373	$1·412 \times 10^6$
77·8	0·0389	$1·354 \times 10^6$
77·4	0·0334	$1·577 \times 10^6$
76·4	0·0316	$1·666 \times 10^6$
75·3	0·0310	$1·699 \times 10^6$
74	0·0268	$1·736 \times 10^6$
72·4	0·0246	$2·141 \times 10^6$
70·7	0·0242	$2·177 \times 10^6$
69·6	0·0240	$2·195 \times 10^6$

These results may be compared with the galvanometer results, because in both cases the temperature was cooling from a point much above melting. Considering the great difficulty of measuring the temperature, the agreement of these results with the galvanometer results may be regarded as very satisfactory.

May 20th. Time roller used for the first time, quick motion only employed—that is, one revolution in two minutes. The battery was kept connected with the plates for intervals of time varying from three to ten minutes before plate A was insulated. The roller curves are in themselves extremely interesting, but we think that to give them in the present Paper would be superfluous. The curve E F gives the values of $\frac{1}{t}\log\frac{E_1}{E_2}$ without con-

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denser from 52°·6 C. to 58°C.; the co-ordinates of the points E, a, b, c, &c. . . . F, have the values given in the following table:—

	Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
	49·7 C.	0·0044	8857 × 10^6
	51·2	0·0050	7794 × 10^6
E	52·6	0·0122	3195 × 10^6
a	54·0	0·0677	575·7 × 10^6
b	54·65	0·1620	240·6 × 10^6
c	55·2	0·3612	107·9 × 10^6
d	57·0	1·7040	22·88 × 10^6
F	58·0	3·2776	11·90 × 10^6
	59	4·1608	9·367 × 10^6

Of the curve G C D, the part from G to C was obtained without using the condenser, and for the part from C to D, the condenser was employed. The co-ordinates of the points C, a, b, &c. . . . D are as follows:—

	Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
C	59·8 C.	0·0065	8·104 × 10^6
a	61·5	0·0096	5·487 × 10^6
b	62·85	0·0097	5·430 × 10^6
c	64·4	0·0126	4·180 × 10^6
d	66·45	0·0138	3·187 × 10^6
e	68·5	0·0193	2·729 × 10^6
f	70·2	0·0250	2·107 × 10^6
g	72·2	0·0267	1·972 × 10^6
h	73·8	0·0285	1·848 × 10^6
D	75·2	0·0293	1·798 × 10^6

Assuming that the paraffin is always in the same state when the thermometer gives the same reading during a regular rise in temperature of the apparatus, we find

$\frac{1}{t}\log\frac{E_1}{E_2}$ without condenser for 59°C. to be 4·36.

$\frac{1}{t}\log\frac{E_1}{E_2}$ with condenser for 59°C. to be 0·0059.

Therefore the ratio of the relative conductivities measured without and with the condenser, is about 740, and hence, assuming the specific inductive capacity of paraffin does not change much with temperature, and that the change of capacity of the pair of quadrants can be neglected, we can calculate the specific resistance in megohms of a cubic centimetre of paraffin wax from our time readings by the following formulæ, which have been employed in obtaining the values of x given above:—

Without condenser,

$$\log x = 7·5908 - \log\left(\frac{1}{t}\log\frac{E_1}{E_2}\right);$$

with condenser,

$$\log x = 4·7216 - \log\left(\frac{1}{t}\log\frac{E_1}{E_2}\right),$$

t being, as usual, measured in minutes.

The changes which occur in the conductivity of paraffin wax when it melts are best seen in the curve A B. It is probable that the curve from E to F represents the continuation of A B to a different scale, and we have found that the further continuation beyond the point F is represented by the curve from C to D, which is again drawn to a different scale.

All the loss of charge observations are combined in the curve G C D, and it is quite evident that there is a decided want of continuity in the curve. It is probable that paraffin follows the logarithmic law until it nears the melting point, but after melting the increase of conductivity would seem to be proportioned to the increase of temperature. The curve C D may be a straight line, but the galvanometer results give a curve which is decidedly concave upwards. It is still, however, a very flat curve.

Solid paraffin, during the four degrees before melting, alters its specific resistance per cubic centimetre from 34000 × 10^6 megohms to 1000 × 10^6 megohms. For the lowest temperature at which it can be said to be melted, its specific resistance seems to be about 10 × 10^6 megohms, and 77°·8 C., to be pretty accurately 1·354 × 10^6 megohms.

Gutta Percha.

The effect of heat on the conductivity of gutta percha was studied by noting the loss of charge of two copper plates separated by a sheet of gutta percha 0·191 centim. thick. The conductivity even at ordinary temperatures was sufficiently great for the employment of a condenser. The values of $\frac{1}{t}\log\frac{E_1}{E_2}$, are shown in the curve O P (Fig. 2), the co-ordinates of the points O, a, b, &c., . . . P of the curve are given in the following table. x, the specific resistance per cubic centimetre in megohms has been calculated from the formula,

$$\log x = 4·7217 - \log\left(\frac{1}{t}\log\frac{E_1}{E_2}\right).$$

The plastic condition of the gutta percha at the higher temperatures has indicated itself in the curve between t and P.

	Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
O	83 C.	0·1052	·5008 × 10^6
a	80	0·1005	·5243 × 10^6
b	77·4	0·0984	·5355 × 10^6
c	76·5	0·0964	·5466 × 10^6
d	70·7	0·0732	·7197 × 10^6
e	70·3	0·0693	·7603 × 10^6
f	70·2	0·0723	·7288 × 10^6
g	70·0	0·0701	·7516 × 10^6
h	69·5	0·0693	·7603 × 10^6
i	68·8	0·0676	·7794 × 10^6
j	64·4	0·0442	1·192 × 10^6
k	62·8	0·0406	1·298 × 10^6
l	61·9	0·0381	1·383 × 10^6
m	60·6	0·0345	1·527 × 10^6
n	59·0	0·0335	1·573 × 10^6
o	57·5	0·0290	1·817 × 10^6
p	56·4	0·0252	2·090 × 10^6
q	55·1	0·0219	2·406 × 10^6
r	53·4	0·0180	2·927 × 10^6
s	52·0	0·0156	3·378 × 10^6
t	50·1	0·0131	4·022 × 10^6
u	48·4	0·0112	4·704 × 10^6
v	47·0	0·0101	5·217 × 10^6
w	45·5	0·0075	7·025 × 10^6
P	44·0	0·0059	8·930 × 10^6

If we may assume that from P downwards in temperature the resistance of gutta percha follows the well-known logarithmic law, we find at 24°C. the specific resistance per cubic centimetre is 83 × 10^6 megohms, showing that for a sheet the gutta percha is fairly good.

Ebonite.

In determining the conductivity of ebonite, we at first proceeded as described above, using a pair of copper plates; but we found that the charge, instead of decreasing through conductivity, increased apparently indefinitely. On replacing the copper plates by sheets of platinum we obtained consistent results, but this may have been due to the sulphur that could easily be liberated by heat having been driven out in the previous heating. Q R is the curve connecting the conductivity, or rather $\frac{1}{t}\log\frac{E_1}{E_2}$, and the temperature. This curve is nearly straight from 65°C. to 96°C., our highest temperature. No rapid change in the conductivity is anywhere perceptible.

As we could not employ the auxiliary condenser in consequence of the resistance of the ebonite being very great, and the loss, therefore, very slow even at high temperatures, and as the specific inductive capacity of ebonite is unknown, we were compelled to make experiments to determine the electric capacity of our arrangement. This was very difficult on account of the small area, 45·6 square centims., of the ebonite in contact with the platinum. The result, therefore, which we obtained, and from which we deduced the specific inductive capacity of ebonite to be 1·7, must only be accepted as very rough, and merely of use in giving us approximate values of the resistance at various temperatures. The number 1·7 seems too small for a composition of india rubber and sulphur. Consequently, all our calculated values of x may be too large, and ought to be reduced in the ratio of 1·7 to the true specific inductive capacity of ebonite.

	Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
Q	36 C.	0·0027	61030 × 10^6
a	41	0·0026	63390 × 10^6
b	46	0·0031	53160 × 10^6
c	48·5	0·0038	43370 × 10^6
d	53	0·0045	36630 × 10^6
e	57	0·0048	34340 × 10^6
f	61	0·0054	35020 × 10^6
g	64	0·0057	28920 × 10^6
h	67	0·0077	21400 × 10^6
i	68·5	0·0076	21690 × 10^6
j	71	0·0086	19160 × 10^6
k	73	0·0093	21560 × 10^6

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l	75	0·0100	16480×10^6
m	77	0·0112	14720×10^6
n	79	0·0120	13740×10^6
o	80·5	0·0124	13290×10^6
p	82·3	0·0133	12400×10^6
q	84	0·0140	11770×10^6
r	85·6	0·0142	11610×10^6
s	87·0	0·0147	11210×10^6
t	88·6	0·0152	10840×10^6
u	90	0·0153	10770×10^6
v	94·4	0·0175	9419×10^6
R	96·8	0·0170	9696×10^6

India Rubber.

The relation of conductivity to temperature of a chemically clean piece of india rubber containing sulphur is given in the curve S T. As the loss was very slow we could not use the auxiliary condenser, and, therefore, had to measure roughly the capacity of the arrangement, which was found to be 0·000208 microfarad. The area of each of the platinum plates, between which the india rubber was placed, was 45·6 square centims. The thickness of the india rubber was 0·106 centim., so that the calculated specific inductive capacity was 4·8. This seems too large; but an error, if there be one, in the determination of the capacity would have made the calculated resistance too small, whereas the resistance is much higher than that hitherto obtained with any of the forms of india rubber experimented on by electricians. We found that the capacity of the electrometer quadrants was neglectable in these, and in the ebonite observations. We give the temperature and the corresponding values of $\frac{1}{t}\log\frac{E_1}{E_2}$, and of x in megohms for the points S, a, b, c, T of the curve S T.

	Temperature. Degrees.	$\frac{1}{t}\log\frac{E_1}{E_2}$	x in megohms.
S	67 C.	0·0100	5391×10^6
a	75	0·0187	2882×10^6
b	81·6	0·0275	1960×10^6
c	86·7	0·0390	1382×10^6
T	90·7	0·0531	1015×10^6

THE LANCASHIRE TELEPHONIC EXCHANGE COMPANY.

This company, which seems in a fair way to becoming a success, and, at the same time, of fulfilling a want which the increased and increasing exigencies of the times has created, has now commenced its operations, having secured eighty-two subscribers. The advantages which the company proposes to confer upon its subscribers is to put them in communication with each other in Manchester at a moment's notice, so that whatever distance they may be apart they may hold converse together by means of the telephone. The instruments used are Bell's telephones, fitted with Blake's transmitters, and it is claimed for them that they are less liable than other telephones to get out of order, as they are all electrical, besides which they are considered to be more sensitive to the human voice than any others. Of course distance is no object, for it will be remembered that in America a conversation has been carried on by means of the telephone through 400 miles of wire. But at present the operations of the company only extend to districts around Manchester and Liverpool. The central office is in Faulkner-street, and from hence wires are carried to the houses or warehouses or offices of all the subscribers. An attendant sits in the office, and when a subscriber desires to speak with another he rings an electrical bell attached to his telephone. The attention of the clerk having been attracted, he requests to be informed with whom the subscriber wishes to converse. Having received the necessary information, he calls, by means of the bell, the person required, and then connects the wires for the two subscribers, who, being informed by the attendant that they are "joined up," can converse together for any length of time with the greatest privacy, it being impossible for any but themselves to hear a word of what is passing. One of the great features of the telephonic exchange is, that should a subscriber desire to speak with two or more subscribers at one and the same time he has only to request the attendant to attach the wires of those subscribers to his own and call their attention to the fact, and he can do so with perfect ease, whatever he says being heard distinctly by all the gentlemen connected, and equally all can hear any reply made by one or other of those who have been listening.—*Iron.*

CORRESPONDENCE.

LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the summer of 1878 delegates were nominated by the following societies, viz., the Royal Institute of British Architects, the Society of Telegraph Engineers, the Physical Society, and the Meteorological Society, for the following purpose:—

"To consider the possibility of formulating the existing knowledge on the subject of the protection of property from damage by electricity, and the advisability of preparing and issuing a general code of rules for the erection of lightning conductors."

The delegates have held several meetings, and have already collected, firstly, from the manufacturers of lightning conductors, and, secondly, from the members of the Royal Institute of British Architects, a large amount of thoroughly practical information. Several of their number are also engaged in forming abstracts of the salient features of the literature of the subject.

The members of the conference are, however, most anxious that their report should be as trustworthy and as exhaustive as possible, and they have therefore instructed me to ask you to assist them by publishing this epitome of their proceedings, and allowing them to invite correspondence upon the points mentioned below.—Yours, &c.,

G. J. SYMONS, F.R.S., Secretary to the Conference.

Lightning Rod Conference, 30, Great George-street, W.

CLASS OF FACTS MOST REQUIRED.

Full details of accidents by lightning, stating especially whether the building struck had a conductor or not. If there was a conductor, state its dimensions, construction, mode of attachment to building, whether its top was pointed, distance of its upper terminal from the place struck, nature and extent of the connection between the conductor and the earth, and whether the earth was dry or moist, whether the conductor was itself injured, and whether the conductor or the point struck was the most salient object in the vicinity. Information is also desired, either verbally or by sketches, as to the position of metal spouting and lead roofing relatively to the point struck, and to the conductor.

Details of the thickest piece of metal melted by a flash of lightning are much needed.

Unimpeachable evidence of the failure of conductors is much desired, as such failures would be extremely instructive.

THE POSTAGE OF THE WORLD.—Dr. Fisher, an *Oberpostrath* of the Imperial German Post Office (corresponding to the rank of assistant secretary with us), has just published an interesting pamphlet showing the comparative postal and telegraphic statistics. But in some cases the information yet available does not enable him to bring down his work later than 1873. The letter post of the whole world for that year amounted in round numbers to 3,300,000,000 letters, or about 9¼ millions daily; and the numbers have been increasing daily at an astonishing rate. Thus in Japan the number of post offices in 1872 was 1,159, and in 1876 it had risen to 3,649. The number of separate articles which passed through the Japanese post in 1878 was 47,000,000, of which 25,000,000 were letters, 10,000,000 post cards, 9½ millions newspapers. Post-cards were first brought into use only in 1865, and now they are employed in almost ever country of the world. The parcels post has, however, not yet got beyond the first stage of its development. The number of telegraphic despatches sent in 1877 amounted for the whole globe to nearly 130,000,000, or an average of 353,000 daily. More than one-third of the total number of telegraphic despatches are private, dealing with purely personal concerns. It is unnecessary to say that the newspaper press absorbs a large proportion of the telegrams of the world, while the world of finance and commerce also appropriates a giant's share.

FRENCH TELEGRAPH LINES.—By the end of the present year 171,500 kilomètres of telegraph system will be in operation throughout France, being an increase within the last decade of 57,831 kilomètres. Great efforts have been made to bring the chief towns of departments into direct communication with Paris, and during last year this was carried out in the cases of Grenoble, Valence, Niort, Douai, Valenciennes, Roubaix, Soissons, Sedan, Mâcon, Chambéry, Toulon, Avignon, Bayonne, Rodez, Gisors, Cambrai, Belfort, Dreux, Granville, St. Lô, and Maubeuge. By the end of the present year Laval, Bernay, Meaux, Pont-Audemer, La Ferté-sous-Jouarre, and Moulins will also be directly connected with the metropolis. Some of the principal lines have been recently duplicated.—*Times.*

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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SUBSCRIPTIONS.

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TELEPHONE EXCHANGES.

Fifteen months ago we called attention to some peculiar phases of American life, and at some length described the exchange telegraph system largely employed in several of the more populous cities in the States, pointing out that, although London had not followed the plan to any great extent, still the Exchange Telegraph Company had inaugurated a system capable of being widely developed, and tending to become a necessity in commercial and domestic affairs. The success of the exchange system was and is undoubted, but its development in England has not been so rapid as we anticipated. It seems, however, that commercial minds, like most others, are greatly influenced by fashion; and as telephones are fashionable, we suppose commerce in England will at length discover that exchanges are necessary. Pioneers of anything useful could probably discuss somewhat feelingly the intensely conservative character of John Bull.

It may be beneficial to direct attention to some of the disadvantages, as well as to some of the advantages, which the introduction of telephonic or similar exchanges will bring in its wake.

The disadvantages are principally those conjured up by physiologists, who insist that life, under present conditions, is hardly worth living. Business and pleasure are carried on at too great a pressure, so that the physique of the nation is becoming gradually but surely degraded. The introduction of increased facilities for communication is by no means an unmixed blessing when viewed from this standpoint. The necessary interruption and change of thought which now take place with each personal interview will be partially avoided by the introduction of the system of telephonic exchanges. Mr. Smith, instead of going from the West End to the City to see Mr. Jones, will merely turn his chair and talk to Mr. Jones through his telephonic connections. It may be, however, that physiologists are all wrong, as statistics point out that the average life of civilised mankind is lengthening instead of shortening, notwithstanding the adverse state engendered by life at high pressure. The degradation on the one hand is probably more than counteracted by increased knowledge on the other hand, which enables us to mitigate if not to abolish many of the dangers which formerly threatened life and health. Whatever the true conclusion may be, there is no difficulty in pointing out a way of escape for overwork. If it can be proved that the average man is incapable of continuously working, with improved appliances, during the same number of hours as at present then arrangements must be made to allow of his working for a less number of hours.

Most of our readers understand the whole system of telegraphic exchanges, so that it will not be necessary to give any lengthy description. Suffice it to say that from a central office lines radiate to subscribers in all directions. At the central office any two lines may be connected so that the subscribers can converse direct. Thus if A, B, C, D, are subscribers, A, on signalling to this effect to the central office, can be put into direct communication with B, C, or D, and *vice versâ*. An example of the immense usefulness of such a system can easily be given. Suppose a stranger, or a person of doubtful means, presents a fairly large cheque for payment in a West End shop. The shop is connected with the central telephone office, the central office is connected with the various banks. The shopman takes the cheque, walks into the inner office as if to get the cash, but before doing so asks to be put into connection with the bank. The connection is made in a moment, and at once a favourable or unfavourable report is returned, and the value of the cheque is ascertained. The time taken to do this ought not to be longer than the time ordinarily taken to get the cash for the cheque. Examples of this kind could be multiplied indefinitely.

In our last issue we discussed the question of local telegrams and the charges in connection therewith, but the officials will have to consider how far the revenue will be changed by the introduction of this new system. There can be no doubt that under certain conditions local telegrams will be almost entirely lost to the Post Office. Whether such a result will end in "telephonic exchanges" passing under Government control or not is a question of the future. Had we any influence over the official mind, we should advise a careful consideration of the question at once, and if the con-

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clusions were favourable an enlargement of the scope of postal telegraphy by the introduction of telephonic apparatus. We long held the impression that no telephonic exchange could be constructed outside of the department, but the inauguration of several companies to carry out such systems would lead us to conclude that our impression was incorrect.

From a commercial, if not from a physiological point of view, we think that a well conducted system of telephonic communication is a great desideratum. The difficulties to be encountered practically before success can be assured are by no means despicable, and much will depend upon the telephones selected for use. Inductive action may in some instances prove an insurmountable obstacle, but the telephone itself seems to be the most important factor. The sounds obtained through the medium of the Bell telephone are very weak, and frequently necessitate a painful strain upon the aural organs to differentiate the vocal from the external sounds. In connection with a microphone as a sending instrument, as suggested by Mr. Crossley, this disadvantage can, to a certain extent, be overcome; but it seems to us that the receiver, at any rate, should be one influenced by a battery, so that the received sounds should depend for loudness not upon the sending instrument so much as on the current from the battery. The experimental instruments sent over by Mr. Edison contained the germs of good receiving instruments, but needed modification to a considerable extent before being suitable for actual use. Whether these modifications have been made—some of which our contemporary, the *Engineer*, suggested when describing the instrument—we do not know; but if clearness as well as loudness can be easily obtained from Edison's receiver, then it will be that best adapted for telephonic exchange purposes. In London, the Gower instrument has scarcely obtained a footing, yet, if we may take the dicta of our Parisian contemporaries, it possesses some advantages over the Bell instrument. The subscribers to any telephone exchange should insist, before finally committing themselves, upon being able to change their instruments, if found unsuitable, for others which may have proved more suitable for their requirements.

NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONTINUED FROM P. 244.)

IV.

Whatever may have been at one time the opinion of Mr. Cromwell F. Varley as to the inefficiency of condensers, in the working of long lines, when these appliances are not circuited through a resistance possessing more or less electro-magnetic inertia, it appears certain that their use was first suggested by this able electrician, whose vigorous originality of thought merits even a wider recognition than that which it obtained in the infancy of the Atlantic telegraph. It occurs to us that this opinion may have been based upon experimental data obtained when a condenser of 150 microfarads, such as has since been used on Atlantic and other long cables, was *non inventus*. We leave for future decision a question suggested by Mr. W. Smith's paper, viz., to whom belongs the credit of originating the very successful method of signalling through long submarine cables, which "has now been in use for twelve years on the Atlantic cables, and has been adopted for working all the cables laid during that period," and which "for speed, simplicity, economy, and accuracy" has not been surpassed. But we would state, as a fact within our own knowledge, that the very existence of "condensers" of enormously high conductive resistance, *i. e.*, of apparatus differing *toto cœlo* from the old tinfoil and gelatine "induction plates," inasmuch as it exhibits induction effects independently of conduction, instead of representing merely a high conductive resistance, is due to Mr. Varley. Mr. Fleeming Jenkin, in his work on "Electricity and Magnetism," apparently gives to Mr. Varley, unreservedly, the credit of introducing such apparatus for submarine signalling. "Mr. Varley's mode of signalling by condensers," says this authority, writing prior to the year 1873, "supplies the means of keeping the light of the mirror galvanometer always at one part of the scale, and the glass tube end of the recorder (Thomson's) within a very narrow strip of paper." He further says that "*Mr. Varley's system* has the additional advantage that no permanent earth currents can flow through the line, for the line is not connected anywhere with earth. And, in accordance with these statements, he gives a diagram showing that the system in question consists simply in the insulation of the cable from earth at each extremity, by connecting the extremities with condensers, of which the opposite coatings are respectively connected to the transmitting key and the receiving instrument.

On the other hand, Mr. Richard S. Culley, writing prior to the year 1871, says, under the heading of *Method of working the Atlantic and other long Cables*:—"The signalling apparatus, as arranged by Mr. Willoughby Smith, and now in use on the Atlantic cables laid between England and India (*sic*), consists of following parts:—

"(1). A very sensitive mirror galvanometer of simple construction, and of a resistance of about 2,000 units; the spot of light is thrown from the mirror on a shaded screen. A movement of the spot of light to the left indicates a dot of the Morse alphabet, a movement to the right a dash, as in the single needle code. These signals are produced by reversing the currents at the sending end by means of

"(2). An ordinary double sending key like that of a single-needle, and

"(3). A battery composed of a small number of cells known as Minotto's.

"As the receiving apparatus is extremely sensitive, it is important to avoid the disturbing effect of earth currents, and for this purpose a *condenser* having a capacity equal to that of 50 knots of the cable is placed between the cable and the *receiving* instrument, the sending key being connected directly to the cable. The condenser is not inserted to increase the *speed* of signalling; in fact it slightly retards it; but it very materially assists in obviating interferences by earth currents." Here we are given to understand that the arrangement of signalling apparatus with a condenser only at the receiving end of the cable is due to Mr. W. Smith, and, further, that the use of one condenser, as described (and, presumably, the use of two condensers) does not augment the speed of signalling; but merely protects the cable from the effects of earth currents. Are we then to conclude that the mere substitution of a Thomson mirror-instrument or re-recorder for a Morse instrument of the maximum delicacy multiplies the speed of signalling fourteen times, and that neither the "curb key" nor the condenser arrangements were ever requisite, so far as signalling speed is concerned? Such questions, unfortunately, are rendered necessary by the dearth of authoritative information as to the methods at various times adopted for working the Atlantic and other long cables, and as to the results obtained by these methods respectively. In the interests of telegraphic science, it is to be hoped that such information, embodying the data most valuable to students, will at some time be forthcoming.

The theory of the "curb key" is concisely given in Mr. Jenkin's text book above referred to; and this theory, which can be readily grasped even by non-mathematical readers, so clearly indicates the advantage of employing some such apparatus that we are almost forced to conclude that its non-adoption must be due to some preponderating advantages, from the point of view of signalling speed, obtained by the use of condensers. But it is to be observed that no theory explanatory of such advantages has yet been brought forward; and, as we have seen, their existence has been denied on very respectable and generally-accepted authority.

The apparatus itself, and the first experiment with it, are so well described by Mr. Willoughby Smith that we cannot do better than to quote his words. "The curb key," he says, is "a mechanical arrangement by means of which three or more currents of equal strength, but of unequal duration, could, in quick succession, be alternately sent into the conductor. By merely pressing an ordinary key the current to give the signal at the distant end was set up, and at the same time a spindle was set rotating, on which were fixed a series of cams, which in quick succession came into contact with the conductor of the cable, and charged it alternately with positive and negative currents. The cam currents had to be so adjusted as to be of insufficient strength to give a signal at the distant end, but were to be regulated so as to neutralise each other, and thus discharge the core for the next signalling current. From actual experiments the patentees had found that from five to seven currents would be practically required to work the Atlantic cable. This was the

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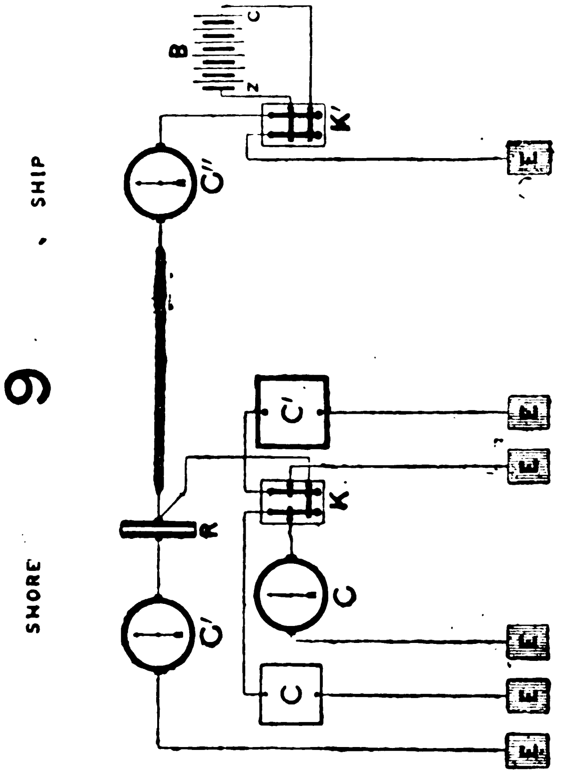
recognised system to be used by the Atlantic Telegraphic Company to work their cable when laid.

"On the same day as the date of the patent a party of gentlemen, at the invitation of the Atlantic Telegraph Company, assembled on board the Great Eastern, then lying at the Nore, to witness the working of the 'curb key' through 2,273 nautical miles of cable, coiled in three tanks on board, but joined in one continuous length. One end of the conductor was attached to one terminal of a marine mirror reflecting galvanometer in the test room on the main deck, and the other terminal of the galvanometer was connected to earth. This was designated the receiving station. The other end of the conductor of the cable was attached to the automatical sending apparatus, or 'curb key,' in the grand saloon, which was designated the sending station. Mr. Varley manipulated at the sending station, and Sir William Thomson, assisted by Messrs. Carson and Tripp, read at the receiving station. The Morse code was used. With a positive current the beam of light was deflected to the left on the scale of the receiving galvanometer, which represented the dot, and with the negative current, the beam of light was deflected to the right, which represented the dash. A disputed speed of six words per minute was with difficulty received while sending the test message."



However insignificant this result may at first sight appear, it seems to offer strong evidence in favour of the apparatus when we consider that the result in question was obtained in face of the terrible obstacle to the transmission of any signal presented by the "false discharge" from the enormous length of coiled cable. It would be most interesting to know what rate of speed was obtained, with the condenser arrangement subsequently adopted, at the period when the greater portion of the cable still remained coiled in the tanks of the Great Eastern. But no experiment on signalling speed appears to have been made until the laying of the cable (1866 Atlantic) was completed. On this point Mr. W. Smith says:—"Of course speed was not the object whilst speaking, as it had to be arranged so as to interfere as little as possible with the regular tests. It was, however, soon apparent that a higher speed would be obtained by the use of a condenser than by the "curb key;" consequently, on the completion of the laying of the cable, the paying out system was continued, and before leaving Heart's Content I had the gratification of seeing a speed of thirteen words per minute attained with perfect ease.

The very successful arrangement adopted in the first instance by Mr. W. Smith in order to render possible the maintenance of a continuous test for insulation and continuity, whilst communications were passing between the ship and the shore, is shown by Fig. 9.

In this figure R is a *quasi* condenser or set of "induction plates," formed of sheets of tinfoil and of gelatine, and acting merely as a conductor opposing a very high resistance to the passage of a current. C and C (the more attenuated of the two similar letterings) are resistance coils of unequal resistance. The remaining portions of the figure explain themselves. "The current which passed through the sheets of gelatine flowed through the galvanometer to earth, and a constant deflection was registered so long as the cable was kept charged at a uniform tension. But if the tension were altered or the direction of the current reversed, the change of the deflection was immediately noticed by the person in charge of the galvanometer on shore, and by this means the person in charge of the batteries on shipboard could by a pre-arranged code of signals communicate with the person in charge of the galvanometer on shore, without interfering with the insulation test. The portion of the current passing through the gelatine plates, R, was only about 0·0025 of the whole charge in the cable (? maximum current that could traverse the cable), which was hardly sufficient to increase the deflection on the ship galvonometer, but nevertheless amply sufficient to give a deflection of two hundred divisions on the scale of the sensitive shore galvanometer." In regard to the arrangement for signalling to the ship, "when one spring of the key K was depressed it allowed a minute portion of the charge in the cable to pass to earth, and thus produce on the ship galvanometer an increased deflection of a few divisions, which was sufficient for the continuity signal, or to represent the dot when speaking. If the other spring of the key were depressed, it would allow double the amount of current to pass to earth, thus increasing the deflection twofold on the ship galvanometer, which, when speaking, would represent the dash, assuming the Morse code to be used." Mr. Latimer Clark and Sir W. Thomson both testified to the perfect working and practical value of this arrangement.

SIEMENS AND HALSKE'S TELEPHONE, WITH HORSESHOE MAGNET AND CALL-APPARATUS.

BY DR. E. ZETZSCHE.*

The telephones lately patented in Berlin for Siemens and Halske are favourably distinguished from other telephones by their remarkable strength of tone, and may thus be used under circumstances in which the older telephones of considerably weaker tone would not be able to force their way right through the noise existing in the space within which they have to be used, which noise is unavoidable in consequence of the work going on within this space. Besides their intensity of tone, these telephones have the advantage of requiring no special exertion or practice on the part of either the listener or the speaker. But as the telephone, since the evaporation of the first enthusiasm concerning it, has almost everywhere, and by no means rightly, vanished from the memory, I will take this opportunity of pointing out once more that the telephone, which in comparison with other telegraphs, is so reasonable in price and so simple in its use, is still in numerous cases a very suitable and useful appliance as a means of understanding, although it can never be of great importance in telegraphic communications, inasmuch as it leaves no objective and lasting signs.

Whilst Siemens and Halske (in the telephones for which they took out a patent about half a year before, and which I have described in my "Handbuch der Telegraphie") sought to avoid the one-sided attraction existing in other telephones towards the membrane or plate of iron in a state of rest, and, by removing the plate into the strong magnetic field between the poles of a powerful horseshoe magnet, to obtain a perfectly equal action of the attracting and repelling forces upon the plate from both sides, they employed likewise, in their latest telephones, a powerful horseshoe magnet, allowing, however (as Bell himself had done in 1877), both poles of the same to work from the same side upon the vibrating plate, but arranging the magnet in such a manner that both the poles entering with the vibrating plate into a magnetic alternation of working could be brought as nearly as possible together.

For this purpose two pole-shoes, n_1 and n_2, surrounded by coils s_1 and s_2, are screwed to the two arms of the horseshoe magnet H (Figs. 1 and 2); the form of these pole-shoes being such as to permit the two poles to be brought as nearly as possible together. Two small iron bars x, are screwed into the arms of H, and between these lies a stronger bar y, which rests excentrically upon its somewhat thicker ends, z, and z_2, let into the woodwork, so that if it be turned round by means of a key or screw-driver fixed in its screw-head z_2, by the bars x it moves the magnet H, and thereby brings the poles of the magnet nearer to the plate P, or, on the other hand, withdraws them from it. Fig. 2 shows the telephone fixed on a pedestal, and thus enabled to stand; in Fig. 1 the telephone is provided

* *Dingler's Polytechniche.*

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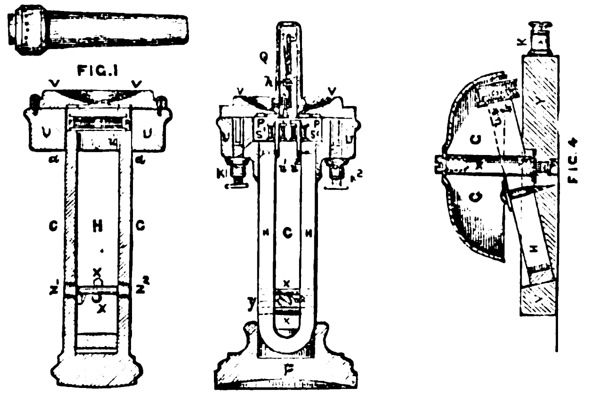
with a handle, and is by this held in the hand. In the opening of the mouthpiece V of this telephone, as Fig. 2 explains, a small tube Q is inserted, which is now made almost double the size represented in Fig. 3; a small metal body with a handle is applied to it in such a manner that it is raised by the vibrating plate P, and then falls back upon it. The drumming produced thereby increases so considerably the sound proceeding from blowing through the tube Q in the receiving telephone that a call-signal uttered thus by means of the tube is to be heard distinctly even at a great distance off. To allow free egress to the air, the tube Q or the mouthpiece V is provided with a number of small air-holes. The clamps K and K_2, which receive the conducting-wires, have lately been constructed in a more suitable form, and are fixed into the woodwork at *a*, *a*; the matrix moves, with a round disc at its inner end, in the hollow cylindrical body of the clamp, and, when screwed in, presses the wire against the bottom of the clamp, a pin in the spindle of the screw preventing the matrix from being quite unscrewed from the spindle. Moreover, also, the outer diameter of the thicker end of the casing, cemented to C, as well as the hemispherical hollow in it, which encloses the coils, have been enlarged by about one-half, so that the diaphragm P might have a diameter of nearly 10 centimètres. The clamps K_1 and K_2, are moreover indicated by the letters K and Z, so that if the telephone is to be applied to a telegraph which is worked by galvanic currents, the copper-pole of the battery may be placed on K, and its zinc pole on Z, because thus the galvanic current does not weaken, but strengthen the magnetism of the horseshoe. The coils s_1, and s_2 are so wound that the same current either strengthens both poles or weakens both.

By means of this telephone the ear can perceive words spoken at a considerable distance from the mouth piece V, and, in the experiments made with this telephone at the Dresden *Polytechnikum* (even with about 3,000 S.U. resistance in the outer circuit)

FIG.3 FIG 2



the mouth of the speaker was distant from V fully one mètre, without the spoken word becoming imperceptible; only when the distance of the mouth from the mouthpiece was increased to about two mètres could the spoken word be no longer heard.

Although the tube just described will in most cases perfectly suffice for the call, yet Siemens and Halske have invented a sympathetic bell which may be used as a telephonic alarum (*Ding.*, 1878, 227,441) with the same magnetic arrangement as in the telephone above described. A section of this alarum is shown in Fig. 4. The bell G rests upon the upright bearer, X, and lies with its rim quite close before the poles *u*, surrounded by coils *s* of the horseshoe H, which is fixed firmly by a wooden screw to the stand Y. If, now, one of several bells of similar tones, and arranged in the same line of conduction, be struck, all the others sound with it.

With regard to the arrangement of telephones in a conducting-line, in which also other telegraphs are to be worked, it must be pointed out that the electro-magnets of the latter do not hinder telephonic speaking. Thus in the experiments which I made late in the autumn of 1878 on the Dresden military cable five kilomètres in length, with the Siemens' telephone above described, four Siemens' needle telegraphs were allowed to remain attached. In the experiments begun during the first half of December upon a stretch of the Dresden fire-alarm telegraphs, a dozen Siemens' needle instruments remained attached during the speaking through the telephone. Here the telephones and the needles are arranged singly behind one another, but the telephones at the end of the speaking were disconnected by the establishment of a short contact.

Now, under these circumstances, if the question be asked, with greater reason than last year, whether the telephone is not applicable to railway traffic, either as a portable telegraph to be conveyed by trains, or—which is certainly more suitable—as an apparatus to be set up in a corresponding number of signal-boxes, and ready in case of need for the passing service for communicating with neighbouring stations, it must be remembered that an application of this kind will break the ice so much the more quickly the more simply and easily the telephone can be attached to the arrangements of the telegraphs already existing on railways. Its use requires now in stations and in signal-boxes the the setting-up of one or two telephones to be used together (for speaking as well as for hearing) and of suitable shunts, so that ordinarily the telephone may not be traversed by the currents which are sent in telegraphing and signalling through the line used for the same purpose. Such a shunt will be absolutely necessary, if the above-mentioned currents are so powerful that they might injure the telephone. In this case, moreover, it will be simplest to summon the station to connect its telephone by a certain call-signal to be sent from the signal-box on an ordinary electro-magnetic alarum placed in an inductive current at rest, and this can be done by means of a simple interrupting keyboard which should be added to the telephone at the signal-box. If the telephone, on the contrary, could be left constantly connected at the stations, so that it would be needful only to take care that the currents flowing through the telephone should not weaken its magnet, but should tend to strengthen it, then the stations could also be called with any telephonic alarum. That these alarums must be in a position to make themselves audible throughout in the stations in spite of a Morse-telegram despatched along the line is a requirement whose fulfilment presents no difficulty, as even the speaking remains throughout audible during the Morse operation which may be going on at the same time. I was able last year already, on considering this last circumstance, to assert the possibility of a simultaneous working with Morse and telephone with simple arrangement of them one behind the other in the same direction. But, as in such an arrangement for duplex telegraphy, the temporary employment of the telephone does not necessitate an interruption of the Morse (telegraph) operations, and because with this arrangement the telephone can be added to Morse telegraphy in the simplest manner, I took the opportunity last November of proving the feasibility of the proposition I had sketched clearly enough last year (in the *Journal Télégraphique*, 1878, 4, 9), by a series of experiments with the Siemens telephones already described. Although these experiments have been made so far only from one room of the Dresden *Polytechnikum* to another, yet it is not to be doubted that experiments on the line, for which I have not yet found time, would have given just as favourable a result.

It is important in this duplex telegraphy that in working the key-board the line for the telephone-currents should not be interrupted. We have thus to produce the Morse signals not by transmitting and interrupting the current, but by strengthening and weakening the current. Here the alternate establishment and removing of a short contact leads to a corresponding connected resistance, or of one battery. We can show the application of the resistance W to the key-board, if the lever of the latter when pressed down upon the work-contact *a* is to produce the signal through the strengthening of the current in the line LL^1; but if this is to be produced by weakening the current, L with W must be removed from *a* to the rest-contact *c*. In some of my experiments there lay in the line constantly, besides a key-board and a Morse apparatus, a resistance of 2,000 S.U., and an additional 2,000 S.U. was connected and disconnected by the motion of the key-board. The author shows the connection of the battery B, whose current is no longer to act along LL^1 after the pressing down of the key-board upon *a*. If both wires were removed from *a* to *c*, then the pressing down of the lever of the key-board would bring battery B in LL^1 only into operation. The short contact of the battery, of course, causes a somewhat larger consumption of battery *matériel*; but we economise the creation of the resistances W in the key-boards. Moreover, the duration of the short contact can be rendered as short as possible by the application of an auxiliary lever to the key-board.

With the ordinary arrangement of the Morse key-board I have made some experiments in duplex-telegraphy. When the key-board was worked slowly, the repeated interruptions of the line in the key-board made the spoken words unintelligible; with rapid working, on the other hand, the thread of speech is not entirely lost. Nevertheless such an arrangement is not altogether to be recommended.

A number of other experiments might be mentioned which have offered further proof of the great sensitiveness of these Siemens telephones. For speaking, these instruments need not be inserted in a current closed and running back into itself, but it is sufficient to connect two telephones by *one* wire, and to stretch wires from their clamp-screws still remaining free, to correspondingly large masses of metal *insulated* from one

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another. Finally, if we lessen the size of these masses of metal, oral communication becomes impossible; yet we may lesson the masses very considerably, without the ear ceasing to perceive in one telephone the working of the inductive-currents excited in the other.

CANTOR LECTURES.*

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece, Electrician to the General Post Office.

Lecture I.

(Delivered Monday, April 21st, 1879.)

It is intended that these lectures shall be confined almost entirely to the narration of the recent advances of Telegraphy in England, for to extend the survey to other countries would compel either the inquiry to be circumscribed or the lectures to be extended. The latter is impossible, and the former is undesirable. Moreover, addressing, as it is believed, a non-technical audience, it is advisable to eschew science and theory as much as possible, and to confine the subject to such simple elementary facts as will bring the whole within the comprehension of all. This will occupy all the time at my disposal.

Ideas are conveyed from mind to mind by means of language. Language is either spoken or written. Speech is composed of certain elementary sounds, which are vowels and consonants; and written language is composed of certain elementary symbols which, in European languages, are letters and numerals. Telegraphy is the art of producing these elements of language at a distance, and when this is done at places beyond the direct reach of the ear and the eye, we call in the aid of electricity, and reproduce these elements by means of electric signals. Hence electric telegraphy.

Now, to comprehend fully how electric signals can reproduce the elements of language, even on the other side of the globe, with the accuracy, rapidity, and facility of the present day, the following questions must be answered, viz:—

1. What is electricity?
2. How is it produced?
3. How is it conveyed from place to place?
4. What is an electric signal?
5. How are these electric signals utilised for the reproduction of speech and language?

The lecture to-night will be confined to answering the first two questions. If we survey this universe in which we live, and move, and have our being, we can reduce everything objective or external to ourselves to matter and to motion. The chemist has reduced matter to nearly seventy simple elements, and the physicist has reduced the motion of the molecules of matter to several modes or forms, among which we enumerate light, heat, magnetism, and electricity. The conception of motion, however, implies the existence of force—of that which produces, or tends to produce, motion—and the application of force to matter, or to the molecules of which matter is composed, means something done, motion produced, or resistance overcome. This something done is called work, and the power to effect work is called energy. Hence, all modes of motion are forms of energy, and, therefore, electricity and magnetism are, like heat and light, mere forms of energy, and in all their effects and all their phenomena we have, in one place, the exact equivalent of work done, or of energy expended, in some other place.

In this box there exists a store of energy (a Grove's battery). It is, at present, quiescent; it is in a potential condition—like the spring of a clock—ready, on being released by the will, to produce active effects, which are called *kinetic*.

Experiment 1. Let us make a connection with this platinum wire. Instantly the energy leaps into activity, throwing the molecules of this wire into that violent motion which we call heat, accompanied by light.

Experiment 2. The energy is now brought to play upon these two pieces of carbon. Again we have heat, but this time accompanied with more brilliant luminous effects.

Experiment 3. Next the energy is allowed to pass through this mixture of water and sulphuric acid—coloured to make it more evident—and instantly it forces asunder the elements of the solution into their elementary gaseous forms, oxygen and hydrogen.

Experiment 4. Now the energy is made to flow around this bar of iron, in which it evokes that peculiar form of energy called magnetism, whereby we are able—(*Experiment* 5)—to attract nails, to hold up iron bars, and—(*Experiment* 6)—to produce attraction and repulsion.

In this way various physical and physiological effects can be produced, all of which are mere reproductions of that energy which has been made potential in the battery, and has become kinetic in the circuit—the technical term applied to the path along which the energy, in its active electrical form, flows. This flow of electrical energy is called the current, and its strength or magnitude depends upon the quantity of electricity that has been thrown into motion in a given time, and this, in its turn, depends upon the potentiality of the energy setting it in motion, and on the resistance or obstacles opposed to its transference. Hence the existence and strength of an electric current simply depends directly upon the energy producing it, and inversely on the resistance opposing its transference.

The energy producing a stream of water is the head or difference of level (difference of potential energy), and the quantity of water flowing to turn a turbine, or work a mill, depends directly on this head, and on the dimensions of the conduit through which it flows. The energy producing a gale of wind is the difference of pressure between different points on the earth's surface. The energy producing a flow of heat between two points is the difference of temperature at those points. Now, the energy that produces a flow of electricity, analogous to differences of temperature and differences of pressure, is the difference of electric potentials, or electromotive force, an extremely appropriate and convenient term, and one which will be probably used a great deal during the lectures. Hence the electric potential of a point is simply the potential energy of electricity at that point. It is a clearly-defined and easily-measured magnitude, and one that has led to a very considerable increase in our knowledge of the nature and theory of electricity.

Another term that will be used a great deal is resistance. The resistance of matter to the transference of electricity is the same relatively as the opaqueness of bodies to the transmission of light, or their diathermancy to the flow of heat. Everything has its own special electrical resistance. When the resistance is small we have conductors; when great, insulators.

The answer to our first question is, that electricity is a form of energy, that it is the exact equivalent of some work done somewhere, that it is sometimes potential, sometimes kinetic. Hence it is always measurable, and, if we only know the electromotive forces and the resistances, we can always calculate the energy present.

How then is it produced?

Electricity is a dual or polar force. It always exists in two forms, which are opposite to each other, and which are hence called positive and negative. A thundercloud, for instance, is positively, the earth below it is negatively, electrified. The air between them is in a constrained condition, and when the charge becomes too great for the air to resist, we have discharge—lightning—and the neutralisation of these two electrical states; to be repeated when the cloud has acquired a fresh charge of positive electricity.

This is an epitome of what takes place in every electrical phenomena. Positive and negative electrical conditions are produced, and are then neutralised. If the action be sudden, we have sparks, shocks, thunder, and lightning; if they be so rapid as to be continuous we have currents.

Now, whenever two dissimilar bodies are brought into contact, energy is developed at their point of contact. If, after contact, they are forcibly parted, the one body will be found negatively the other positively electrified, or there will be a difference of electric potential between them. Hence static electricity and the electrical machine. If such bodies remain in contact, we have still a difference of electric potential. If the one be a solid and the other a decomposable liquid, we have also chemical affinity, and the intensity of the chemical affinity is dependent on the amount of this difference. This constantly brings fresh surfaces into contact, and hence we have continuous electrical action going on or a current produced.

Now, such a converter of energy is called a galvanic battery. Zinc is almost invariably one body used, various chemical solutions the other.

A battery produces electricity by the combustion of zinc as a fire produces heat by the combustion of coal. To obtain heat from coal, however, it is only necessary to light it in the presence of air, whereas to obtain electricity from zinc a special combination of that metal with another metal or conductor and a liquid is required. The liquid must be one which has a strong chemical affinity or attraction for zinc, and the second metal or conductor must be one for which the liquid has no, or very little, affinity. Sulphuric acid in one shape or another is the liquid which is generally used, and the second conductor is generally either copper or carbon. The combustion of coal in air produces carbonic acid gas, which immediately passes away up the chimney and is lost, but the combustion of zinc in a battery produces sulphate of zinc, which remains, and becomes an article of sale.

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* From the *Journal of the Society of Arts* for October, 1879.

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The carbonic acid gas escapes from the fire of itself, but the sulphate of zinc has to be removed from the battery, otherwise it would stop its action.

The arrangement of a piece of zinc and a piece of copper or carbon in a liquid to produce electricity is called a cell, and a series of such cells properly arranged is called a battery.

The Simple Voltaic Cell.

Experiment 7. If a glass jar or earthen pot, say of quart size, be half filled with water, into which one ounce of sulphuric acid is poured, and if a pure zinc rod with a piece of copper wire soldered to it be immersed in the acidulated water, no change whatever will be observed, but if a plate of copper with a wire attached be also immersed, and the two wires be connected together, then the zinc at once commences to be attacked, and bubbles of gas are copiously given forth from the copper like the bubbles in soda water.

As long as the wires or straps attached to the zinc and copper are kept apart, no action takes place, but the zinc has acquired negative and the copper positive electricity; but the moment they are connected voltaic action begins, the zinc is consumed, the electricities are neutralised, and currents flow. The current flows from the zinc through the liquid to the copper, and thence through the wire back to the zinc; the zinc combines with the sulphuric acid, forming sulphate of zinc, and hydrogen is given off on the copper. Hence, in process of time, all the zinc would be converted into sulphate of zinc; but the action of the cell ceases before this can occur. The water will only dissolve a given quantity, and when this point, called the point of saturation, is reached, the sulphate will form in white transparent crystals on the zinc, and isolate it from the liquid. Again, the hydrogen, in forming on the copper, leaves less of the plate in contact with the liquid, and "polarises" it, as it is called—that is, it causes it to set up an electrical effect in opposition to the prime current; it also reacts on that portion of the sulphate of zinc which is still dissolved in the liquid, causing zinc to be deposited on the copper plate itself. The deposit of crystals on the zinc can be provided against by care and attention in any cell, but that of zinc on the copper plate cannot be obviated in the simple voltaic cell; and cells of a different kind have, therefore, had to be adopted, as will be shown hereafter.

This was the form of battery with which Faraday made all his researches, and also that which was made in all the earlier telegraphs in England. The cases were filled with sand (moistened with sulphuric acid) to make the battery portable. But owing to the existence of impurities in the zinc, great local action occurred, which, though checked by being rubbed with mercury—amalgamation—led to such waste and irregularity, that the introduction of the sulphate, or Daniell's form of the cell, by Mr. John Fuller in 1852 was a very great step in advance.

In the cell the zinc is called the positive plate or element, and the copper is called the negative plate or element. Outside the battery the copper end is called the positive pole, and the zinc end the negative pole. This seeming contradiction of calling the copper plate in the battery the negative element and the wire connected with it outside the positive pole, and similarly calling the zinc plate the positive element and the wire connected with it the negative pole, is explained by the fact that the electricity produced by the chemical action on the zinc or positive plate, as already shown, passes through the liquid in the cell to the copper plate, and from the copper through the wire connecting the two plates back to the zinc; thus positive electricity flows from the negative plate, and the wire connected to this plate is, therefore, called the positive pole.

Daniell's Battery.

Daniell succeeded in removing the hydrogen from the copper by placing the copper plate in a solution of blue vitriol or sulphate of copper, the zinc remaining in dilute sulphuric acid, and the two liquids being separated from each other by a porous material, which, while it checked the mixture of the liquids, did not prevent the flow of electricity. The action of this cell is like that of the simple one, sulphate of zinc being formed in the dilute sulphuric acid, and hydrogen being produced on the negative plate; but the hydrogen at once decomposes part of the sulphate of copper in which the negative plate is placed, throwing down upon that plate pure metallic copper, which keeps it bright and clean, and forming fresh sulphuric acid, which passes through the porous plate to the zinc, and forms sulphate of zinc. There are three kinds of Daniell's battery in common use, viz., (*a*), the ordinary, introduced by John Fuller; (*b*), the chamber, introduced by John Muirhead; and (*c*), the U.K., so called because it was used by the United Kingdom Telegraph Company.

(*a*) The Ordinary Sulphate Battery.

A trough, 2 feet long, 4 inches wide, and 5½ inches deep, is made of teak and divided into 10 cells by slate partitions. To make it water-tight it is coated internally with marine glue, which is a mixture of india rubber, naphtha, and shellac; each cell is then subdivided by a porous partition of unglazed porcelain, about ¼ inch thick, which is fixed while the marine glue is hot. A zinc plate is placed in one of these divisions, and a thin copper plate, 3 inches square, in the next one, and so on, until the 10 cells are occupied. The copper plate of one cell is permanently connected with the zinc of the next cell by a copper strap cast into the zinc and rivetted to the copper, which is easily bent over the slate partition.

The last copper and the last zinc plate are each connected to brass binding screws or terminals, which become respectively the positive and negative poles of the battery. To charge a battery, though apparently a very simple operation, it is necessary to carefully observe a certain routine, and for the ordinary sulphate battery the following details are generally carried out.

About 3 ounces of sulphate of copper crystals, which must be in masses of about the size of hazel nuts, are placed in the copper divisions, filling them to about one-third of their height, and pure water (hard water should never be used) is then poured in until it reaches the same level as the top of the zinc plates. A little time is then allowed for the copper sulphate solution to force the air out of and saturate the porous plates, and when this process is observed to be complete, the zinc divisions are filled with pure water to within a quarter of an inch of the top of the zinc plates. As the porous plates will have absorbed water from the copper divisions, they must be gone over again and filled to the same level as the water in the zinc divisions.

The ordinary action of this battery is:—Zinc is consumed, sulphate of zinc is formed, sulphate of copper is decomposed, and pure copper is deposited on the copper plate. If all the materials were pure, and no causes of interference were present, it would simply be necessary to remove occasionally the sulphate of zinc and replace the sulphate of copper; but the solution of sulphate of copper diffuses through the porous partition, the sulphuric acid leaves the copper and attacks the zinc, for which it has a greater affinity. Pure copper, in the form of black mud, is then deposited on the zinc plate, and the action of the battery is weakened.

Zinc, again, cannot be obtained pure, and the particles of lead, iron, and other matter which are mixed with it set up local action, which is evidenced by the way in which the plate is pitted.

The porous partitions contain impurities—coke and metallic dust—which also set up local action, and cause copper to be deposited upon them.

(*b*) The Chamber Battery.

A box, 2 feet 2 inches long, 5 inches wide, and 5¾ inches deep, is made of deal, without any partitions. Five vessels of glazed porcelain or ebonite, forming 10 cells, are fitted into this trough.

Into each cell is put a porous earthenware pot, in which the copper plate is placed. The size and arrangement of the plates and the mode of fitting, charging, and maintaining the battery, are precisely the same as in the ordinary battery. In many places the wooden box is dispensed with, and the earthen "chambers" are simply ranged on the shelves or racks of the battery room, but always covered with some protection to check evaporation. This plan of placing the cells without casing on shelves is convenient for increasing battery power, as two, four, six, or any other number of cells can easily be added at any time. The chamber battery offers every facility for cleaning, and it is more easily handled than the ordinary form; cracked and imperfect porous pots are very easily replaced, but there is more local action, and it is, therefore, more wasteful. This wastefulness is, however, checked to a certain extent by saturating the porous pot, except at the part immediately opposite the zinc plate, with melted paraffin, and thus preventing diffusion, the principal cause of waste. Great care must be taken to keep the non-saturated side of the porous pot opposite the zinc plate.

(*c*) The UK Battery.

This battery takes its name from the initials of the late United Kingdom Telegraph Company, who used it to a very large extent upon their system prior to the transference of the telegraphs to Government.

In this battery each cell is a round earthenware jar, 5 inches high by 4½ inches wide, holding two pints. The porous pot is saturated with paraffin for half an inch at its base and at its top. It sometimes stands upon a gutta percha tripod. The copper plate is curved and fixed just outside the porous pot. The zinc is circular, and weighs 2¼ lbs. Crystals of sulphate of copper are placed inside the copper, and the cell is charged and cleaned in the same way as the cells of other forms of Daniell's battery. The cylindrical shape of the copper and zinc plates offers a very large surface for chemical action, and at the same time mini-

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mises the internal resistance, thus increasing the strength of the current, which of course is a great advantage in the working of long circuits, especially when the insulation has fallen comparatively low.

Faults Prevalent in Daniell's Batteries.

(*a*). *Leaky Cells*.—The marine glue chips off, and the joints fail, one cell leaking into another; or the same thing happens with the fixture of the porous cell; or the porous jar itself is cracked. The result is complete loss or great reduction of power. This is easily remedied temporarily by bridging the faulty cell across with a piece of wire or strip of metal.

(*b*) The porous jar sometimes becomes so hard as to offer sufficient resistance to the current to reduce it greatly. The remedy is the same as in the last case.

(*c*) The porous jar is at other times too soft, and causes an unequal diffusion of the liquids, so that the liquid in the copper division becomes higher than that in the zinc division. This can be checked by a little acid, but time is the best cure. If time fails to work a cure, the jar should be removed.

(*d*) Dirty connections are the most frequent source of failure, and cleanliness is the only cure.

(*e*) The zinc plate becomes much corroded at the level of the liquid. This is due to the presence of too much free sulphuric acid; the result of some local action. This, however, is a very rare fault, and one that soon ceases.

(*f*) Local action works out one cell before all its neighbours. The copper division is found to be full of clear water. It should at once be supplied with crystals. Indeed, the liquid should always be blue.

(*g*) Occasionally a battery makes earth on a damp support, but this can always be guarded against by care.

Gravity form of Ordinary Battery.

As the porous cells are costly and troublesome, Mr. Cromwell Varley proposed to dispense with their use by taking advantage of the different specific gravities of sulphate of copper and sulphate of zinc to keep the two solutions together. He made what is called the "gravity" battery, but our experience of its use in England did not justify its retention in practice, though in different forms it has become very extensively used in France, India, and America.

One of the greatest improvements ever made in batteries was that made by M. Leclanché.

(TO BE CONTINUED.)

TELEGRAPHY IN WAR.

Sir Evelyn Wood, V.C., in his speech made on the occasion of his being presented with a sword of honour at Chelmsford on Tuesday, the 14th of October, paid a tribute of praise to telegraphy. He said, "But my obligations as a soldier are not confined to soldiers. In the last Caffre war, Mr. Wright, the director of telegraphs, did more for soldiers than is generally known. In the years 1847, 1848, 1851, 1852, and 1853, the information of the Caffres was always in advance of our own. In 1878, Wright had, in spite of all dangers, pushed his wire through Caffraria, and he transmitted to all stations daily accounts of the operations. Thus, when the Galikas, after being beaten by Sir Arthur Cunyngham, sent to the Gaikas announcing a victory and urging an immediate rising, the messengers were astounded by the incredulity of their friends."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The directors of the West India and Panama Telegraph Company (Limited) report that the revenue for the six months ended 30th June last was £39,132, and the expenses £22,065, leaving a net income of £17,067, to which £2,225 brought forward has to be added. Out of the total of £19,292 thus provided, £5,000 is placed to reserve, and after paying dividends at the rate of 6 per cent. on the first and second preference shares and paying £891 on account of cost of reconstruction and liquidation, a balance of £1,631 is left to be carried forward. The traffic receipts of the half-year show a falling off amounting to £2,471, due to frequent interruptions and depressed trade. On the other hand, the expenses show an increase of £4,486, which is more than accounted for by the additional cost of ships and repairs, that being £5,183 more than in the first half of 1878. The sum of £22,882 was spent on repairs, and there were 13 interruptions. The colony of Demerara has intimated its intention to deduct £1,000 from its subsidy, on the ground of these interruptions, and against this decision the directors make strong complaint.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

Report of the directors for the six months ending 30th June, 1879, to be presented at the twelfth ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, in the city of London, on Wednesday, the 22nd day of October, 1879, at 2 o'clock:—The directors herewith submit the usual statements of account for the half-year ending 30th June, 1879. The gross receipts for that period have amounted to £150,107 11s. 5d., against £135,482 15s. 11d. for the corresponding half-year of 1878, giving an increase of £14,624 15s. 6d. The working and other expenses, including a sum of £11,185 18s. for cost of repairs and maintenance of cables, together with interest on debentures and income tax, absorb £65,509 14s. 8d., leaving £84,597 16s. 9d. as the net profit for the half-year. Two quarterly interim dividends of 1¼ per cent. each, amounting to £49,937 10s. have been paid, leaving a balance of £34,660 6s. 9d. to be carried forward. The s.s. Edinburgh being no longer required, has, since her return to England, been sold for £10,000. The contract with the Governments of New South Wales and Victoria, referred to in paragraph 8 of the last report, was signed and sealed on the 6th May last, and the additional capital authorised by a resolution passed at the extraordinary general meeting, held on the 4th December, 1878, has been raised by the issue of 6,400 debentures of £100 each, bearing interest at the rate of 5 per cent. per annum, and redeemable within twenty years. The directors have the pleasure to announce the successful laying by the Telegraph Construction and Maintenance Company of the first section of the duplicate cable to Australia, viz., between Penang and Singapore, connecting Malacca on the 16th August last. The manufacture of the remaining portion of the cable required to connect Singapore with Australia is nearly completed, and a considerable amount has been shipped. A concession from the Spanish Government for connecting Manila with Hong Kong is offered to this company. The concession is exclusive for 40 years, and grants an annual subsidy of $48,000 or about £9,600 for ten years. The cost of acquiring and carrying out the concession will be £120,000. The estimate of revenue shows the concession to be advantageous, and resolutions will be submitted to the extraordinary general meeting to be held at the conclusion of the ordinary general meeting, authorising the Board to take the necessary steps for acquiring and carrying out the same.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 15.		Business Done Week Ending Oct. 15. Highest.	Lowest.
Anglo-American Ordinary ......ex div.	58,	⅜	59½	57¾
Do. "B" ......ex div.	83¾,	4	85¼	83¾
Do. "A" ......ex div.	34,	¾	35¾	33¾
Brazilian	6 15-16,	7 1-16	7¼	7 1-16
Cuba	7¾,	8	8⅛	7¾
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference...x d.	11¼,	¾	11⅜	11⅛
Direct United States	11¼,	¾	11⅝	11¼
Eastern ......ex div.	7 15-16,	8 1-16	8 3-16	8
Do. Six per Cent. Debenture.ex div.	102,	105	103	103
Do. Five per Cent. do	102,	104	—	—
Do. Six per Cent. Preference.x div.	11¾,	12	12¼	12
Eastern Extension ......ex div.	7 15-16,	8 1-16	8 3-16	8
Do. Six per Cent. Deb.	105,	108	—	—
German Union	7,	¼	—	—
Globe Telegraph and Trust......ex div.	5⅛,	⅜	5⅜	5 3-16
Do. Six per Cent. Preference...x d.	11⅛,	⅜	11⅜	11¼
Great Northern	8⅝,	⅞	8¾	8½
Indo-European	21,	23	23¼	22⅜
Mediterranean Extension	2¾,	3¼	—	—
Do. Eight per Cent. Preference	9¼,	¾	—	—
Reuter's ......ex div.	9,	10	9¾	9½
Submarine	225,	230	230	229
West India and Panama	1⅜,	⅝	1 9-16	1⅜
Do. Six per Cent. Preference	7¾,	8	7⅞	7¾
Western and Brazilian	3¼,	½	3⅜	3 5-16
West. Union Seven per Ct. 1st Mt.	120,	125	—	—
Do. Six per Cent. Sterling	105,	107	106¼	106

TRAFFIC RECEIPTS FOR SEPTEMBER, 1879.

Companies.	Sept. 1879.	Sept. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,463	537	—
Direct Spanish Telegraph Company	1,121	1,048	73	—
Direct United States Telegraph Company	—	—	—	—
Eastern Telegraph Company	39,369	38,169	1,200	—
Eastern Extension Telegraph Company	26,980	22,151	4,829	—
Great Northern Telegraph Company	18,775	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	1,200	—	—	—

Electric Light Reflectors.—P. E. Chappuis, Manufacturer, 69, Fleet-street. —[Advt.]

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NOTES.

CASPIAN SEA CABLE.—This cable, manufactured by the India Rubber, Gutta Percha, and Telegraph Works Company, was successfully laid on Oct. 14, under the supervision of Lieutenant Bohr.

CALCUTTA.—The bust of General Robinson, Director-General of the Telegraphs in India, executed by Mr. E. E. Geflowski, has been placed in the Telegraph Hall, at Calcutta. It is pronounced an admirable likeness.

WIDNES.—At the last meeting of the local board, it was recommended that a telephone should be arranged to connect the old and the new offices of the board. The cost of the telephonic apparatus required was stated to be about £50. Surely this is indicative of progress.

THE TELEPHONE.—Three different telephonic companies are competing in Paris, viz., the Gower (magnetical), Bell, and Edison, the two latter working with the microphone. It is said that the Bell and Edison Companies will enter into a working arrangement, or a fusion.

TELEGRAPHY IN WAR.—(A correction). The accuracy of *The Times* in its reports is generally acknowledged, but we find *The Times* is liable to error. In our last issue we quoted a paragraph from Sir E. Wood's speech, in which a Mr. Wright was credited with great activity in telegraph matters in South Africa. A number of correspondents remind us that the gentleman who has shown so much energy is Mr. Sievewright.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY, SILVERTOWN.—We are glad to announce that this company has completed laying, between Marseilles and Algiers, the new cable manufactured by them for the French Government. They have also repaired the old cable, and both are now in operation. We understand that this company is manufacturing for our own Telegraph Department a short cable for the Irish service.

FATAL ACCIDENT AT EAST GREENWICH.—A fatal accident occurred on the Telegraph Construction and Maintenance Company's cable ship Scotia, during the shipping a cable off the company's works at East Greenwich. Samuel Parsons, aged 46, of 53, Oscar-street, New-town, Deptford, was descending a ladder to reach the hold where the cable is being coiled, when he fell and received such severe injuries that he expired on the way to the Seamen's Hospital.

SYNCRONOME CLOCK AND ELECTRO-MAGNETIC MOTOR COMPANY (LIMITED).—A company with this title has been registered with a capital of £20,000, in shares of £2. The Company is formed to purchase or otherwise acquire, develop, and carry on the manufacture of clocks of every description, and for converting electric force into motive-power. The subscribers are: H. Port, Birmingham, 250 shares; J. Austin, Birmingham, 50; J. Sketchley, Birmingham, 50; H. Horton, Birmingham, 50; W. Austin, Birmingham, 50; G. Bats, 147, Dynevor-road, 10; T. Varley, Walthamstow, 250.

THE PROGRESS OF THE TELEPHONE.—M. Léon Say, the French Minister of Finance, is establishing telephonic communication between his château at Stors and his ministerial residence in the rue de Rivoli. Pending the completion of the telephonic line, a telegraph wire between Paris and Asnières was recently pressed into the service for an experimental trial, at which M. and Mme. Léon Say, the Duke, Count and Countess of Montebello, and several of their friends were present. Conversation was perfectly carried on through the distance of 31 miles between Paris and Stors, "not a word," it is said, "being lost."

THE ELECTRIC LIGHT ON THE THAMES EMBANKMENT.—The first experiment with 20 lights was commenced on the 13th of December, 1878, the second with 40 on the 16th of May last, the third with 55 lights on the 10th of October. The length of the circuit on the west side of Waterloo Bridge is 6,007ft., of that on the east side, 6,092ft. Since the 13th of December last to the 9th inst. the lights have been burning 1,374 hours, during which time there have been consumed 27,997 candles. The total length of conducting wire is 17 miles 361 yards, to be increased when the Board of Works board room is lighted to 18½ miles. The ten new lights on Waterloo Bridge are worked by a 20-light Gramme machine in two circuits.

THE INDUCTION COIL.—Reviewing the new edition of "Noad's Text Book," the *Journal of the Telegraph* says:—"The invention of the induction coil is credited to MM. Masson and Breguet, in 1842." As a matter of fact, the first induction coils were made by Professor C. G. Page, then of Salem, Mass., in 1837-8, consisting of a long secondary wound over a short primary coil, having a bundle of iron wires for its core, and provided with an automatic circuit-breaker. They were capable of giving sparks in free air, as well as shocks and other indications of high potential. The fact that descriptions of this apparatus were published in the scientific journals of the day leaves no adequate excuse for the persistent omission of many European authors to give the credit of this apparatus to the American inventor to whom it rightfully belongs.

CANADIAN TELEGRAPHS.—The latest Government statistics giving details for 1878 state that the telegraphs of the Dominion comprise (1) the Pacific Railway line of Telegraph, (2) the British Columbia Telegraph system, from Victoria, Vancouver's Island to Cariboo. As regards the former of these, the telegraph line between Fort William and Selkirk, 410 miles, is in use. The line has been constructed from Selkirk to the longitude of Edmonton, 1,197 miles, and is in operation to Battleford, 967 miles. In British Columbia the telegraph is ready to be put in operation from Cachi Creek running easterly to Kamloops, 50 miles. The line is partially cleared 55 miles north of Kamloops. As regards British Columbia, the telegraph is in operation over an extent of 634 miles. There is also a branch of ten miles from New Westminster to Burrard's Inlet, constructed by Messrs. Moody and Co. The expenditure during the year was 36,662.94 dollars, the revenue was 8,790.35 dollars.

CITY AND GUILDS INSTITUTE.—The City and Guilds of London Institute for the Advancement of Technical Education announce the opening of their technical classes, at

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Cowper-street School, Finsbury. In the section of Applied Physics, Mr. W. E. Ayrton will deliver a course of twelve lectures on "Some of the Practical Applications of Electricity and Magnetism," commencing Monday, November 3rd, at seven p.m. In that of Applied Chemistry, Dr. H. Armstrong, F.R.S., will deliver a similar course on "The First Principles of Chemistry," commencing Wednesday, November 5th, at eight p.m. An inaugural lecture will be delivered by Mr. Ayrton, on Saturday, November 1, at eight p.m., on "The Improvement Science can Effect in our Trades, and in the Condition of our Workmen." A syllabus of each course of lectures can be obtained at the halls of the companies of Mercers, Clothworkers, and Drapers, or at the Schools, Cowper-street, Finsbury. Intending students should send in their names to the demonstrator, Cowper-street Schools, Finsbury, E.C. The inaugural lecture will be free.

The Prelude to the Fight.—The following circular has been issued by the directors of the Anglo-American Telegraph Company. No information as yet has reached the public to the effect that the new French Cable has been laid, but the directors of the Anglo-Company are evidently determined that their French rivals shall know the fate in store for them in good time :—

"Anglo-American Telegraph Company (Limited).
"26, Old Broad-street, London, E.C., Oct. 20.

"Sir: I beg to inform you that the directors of this company have resolved, from the day of the opening for traffic of the new French Transatlantic Cable, laid down by La Compagnie Française du Télégraphe de Paris à New York, to reduce the tariff of the Anglo-American Telegraph Company, *viâ* Valentia or *viâ* Brest, for messages between the United Kingdom or France and New York and Canada, to 6d. and 60 centimes per word respectively.

"In order to provide for the large increase of business which it is anticipated will be the result of this reduction, a new cable will be laid by this company in 1880. Due notice will be given of the exact date upon which this new tariff will come into force; but it is considered desirable to send you this preliminary notice, as similar ones have been forwarded to various telegraph administrations and other official public bodies.—I am, Sir, your obedient servant,

"H. Weaver, General Manager."

Conservation of Energy.—In a paper read before the Canadian Institute, by Mr. J. Galbraith, M.A., C.E., the following conclusions are drawn :—(*i*) On the *theory of action at a distance.* (*a*) That the principle of conservation cannot hold in nature. (*b*) The term, Potential Energy, from its definition, is incapable of strict application to any natural system of bodies. (*c*) The principle of conservation, regarded merely as expressing periodical restorations of actual energy, cannot hold in nature. (*ii*) On the *theory of action by contact.* (*a*) The principle of conservation of *actual* energy depends on the nature of the atoms. (*b*) The conservation of relative motion, after impact, can only hold in the collision of rigid bodies. (*c*) The assumption of rigid atoms is, therefore, necessary to the conservation of actual energy, which assumption may be made, as it involves nothing inconsistent with nature; but, on the contrary, makes possible the explanation of a wide range of natural phenomena, otherwise inexplicable. (*d*) There is no such thing as dead pressure. All forces, pulls, thrusts, frictions, attractions, repulsions, &c., consist of collisions. That there should be action between two bodies, without relative motion, is inconceivable. (*e*) The use of the term Potential Energy, even when the forces are of the above kind is inadmissible, since it implies results with regard to which the principle of conservation makes no assertion, and thus leads to false idea regarding the principle.

A New Work on Electricity.—This work, by Mr. J. E. H. Gordon, referred to in a previous issue, is divided into four parts. Part I. treats of *Electro-Statics*, including chapters on Preliminary Experiments, Electric-Machines, Quantity, Density, Physical Conception of a Medium Necessary for Electric Force, Potential, Electrometers, Absolute Measurement, Leyden Jar, Specific Inductive Capacity, &c. In the chapter on the last of these subjects the experiments of Cavendish, Faraday, Schiller, Boltzman, Hopkinson, Gordon, Ayrton and Perry, &c., are described. Part II. treats of *Magnetism*, and has chapters on Definitions, Terrestrial Magnetism, New Instruments, &c., Self-recording Instruments, Results of Astronomical Observations, and Earth Currents. Part III. deals with *Dynamical Electricity and Electro-Magnetism*, with chapters on Batteries, Action of Currents, Resistance, and Measurements, Galvanometers—Theory and Construction, &c., Electro-Magnetism, B.A Units, Mutual Action of Currents, Relation between Variation of Potential and Strength of Current, Currents Produced by Induction, &c., Standard Coils, Electro-Magnets, Induction Coils, Relation between Electricity and Heat, Contact Theory, Electrolysis, &c. Part IV. considers the *Relations between Electricity and Light*, containing chapters on Experiments of Faraday, Becquerel, Gordon, Kerr, &c., Effects of Light on Selenium, Clerk Maxwell's Theory, &c. The whole work has been admirably illustrated at great expense by the publishers, Messrs. Sampson Low and Co.

Prediction of the Microphone.—The *Woman's Journal* speaks of Antoinette Brown Blackwell as predicting the microphone, because of the following paragraph in a work published in 1876 :—"It remains to invent some instrument which can so retard the too rapid vibration of molecules as to bring them within the time adapted to human ears; thus we might comfortably hear plant movements carrying on the many processes of growth, and possibly we might catch the crystal music of atoms vibrating in unison with the sunbeams. Sound can be refracted by passing it through a lens which retards its motion. Such an improvement upon the stethoscope would reveal phenomena but little more marvellous than those already offered us by the telescope and microscope." Doubtless this is very pretty, but as a prediction of the microphone it is absurd. To predict an instrument is practically to construct it, or at least give the broad mechanical principles upon which it is based. If we were to say that undoubtedly the future men of science will have means of examining the hypothetical substance called ether, or the means of proving its non-existence, is not predicting the instrument by which this may be done. There is a miserable tendency to deprive inventors and discoverers in physical science of the just acknowledgment of their work, and the method adopted to deprive them of due honour cannot be otherwise than contemptible. The fashion of saying so and so has not done much after all, for the work was predicted here, or suggested there, or Mr. A. at the Antipodes anticipated the discovery in theory if not in fact, and so on, cannot be too strongly condemned. Lately everything done in England is claimed by our cousins in America. Surely we are not yet degenerated into a state of imbecility, that we can do nothing, and are dependent on them for all. We in England, as a rule, take every possible precaution to find out if the invention or discovery is original before claiming it, whilst we fear the custom in America is to patent everything that can be patented without due investigation of what has been done elsewhere.

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CANTOR LECTURES.*

RECENT ADVANCES IN TELEGRAPHY.

By W. H. PREECE, Electrician to the General Post Office.

LECTURE I.

(CONCLUDED FROM PAGE 264.)

THE LECLANCHÉ BATTERY.

The Leclanché battery is made thus :—

Into a glass jar a solution of the ordinary commercial sal ammoniac (which is a combination of hydrochloric acid and ammonia) is poured. A zinc rod or plate, into which a connecting tinned iron wire has been cast, is then placed in the solution, and a plate of carbon surrounded by a mixture of broken gas-carbon (or coke) and peroxide of manganese, is fixed in a small porous pot at the top of the jar. To make an attachment for the terminal the top of the carbon plate is capped with lead, which makes good metallic contact with the carbon, and is not liable to be attacked by ammonia, as brass would be. The carbon plate is then dipped in melted paraffin to fill up its pores and to check the exclusion of the liquid by capillary action.

Lastly, the wire, the top of the zinc rod, and the lead cap of the carbon plate are covered with pitch, ozokerit, marine glue, or some other compound, to protect them from local action.

THE ACTION OF THE BATTERY.

The action of the battery is to dissolve the zinc and form zinc chloride, and some other salts of zinc which are not soluble in water but are soluble in a solution of sal ammoniac and water; to reduce the peroxide of manganese to a lower oxide, and to form ammonia, which is given off as a gas. Thus, after a time new zinc will be required, the sal ammoniac must be replaced, and the porous cell which contains the peroxide of manganese must be renewed. When the solution of sal ammoniac becomes too weak to dissolve the zinc salts, they form themselves in crystals on the zinc rod and porous pot; and if the solution becomes too highly charged with these salts (super-saturated) the crystals form in the substance of the porous pot and crack it. This is prevented by a periodical renewal of the sal ammoniac solution.

There is no local action or waste of material when the battery is not in action, so that if the evaporation of the liquid is prevented it may be allowed to remain untouched for months without losing power. The time the battery will last is entirely dependent on the amount of work it has to do.

It polarises so quickly that it should not be employed for local battery purposes or for double current circuits, or circuits where permanent currents are used.

FAULTS PREVALENT IN THE LECLANCHÉ BATTERY.

The cracking of the porous pot, due to the formation of crystals in its pores. The corrosion of the connecting iron wires, due to the action of ammonia. The disconnection of the connecting wire of the carbon plate, due either to the lead cap making imperfect contact with the carbon, or to the formation of salts of lead between the lead and the carbon. The cracking of the glass jar, due to imperfect annealing.

The Leclanché possesses a great advantage over the Daniell battery, where only a comparatively small amount of work is required, because the Daniell, when left to itself, becomes weakened by local action to almost as great an extent as if it were in work, which is not the case with the Leclanché. But the Leclanché, if worked hard, rapidly polarises and becomes unfit for use. Where a moderate amount of work is required, it is an admirable battery, and requires a minimum amount of attention.

THE "GRAVITY" FORM OF THE LECLANCHÉ BATTERY.

This is designed specially to utilise troughs which have been made for Daniell's batteries. The porous divisions are removed from the trough. The carbon plate is inserted, passing through the zinc plate. The bottom of the cell is charged to nearly half its height with crushed gas retort carbon and peroxide of manganese. Sal ammoniac is placed on the zinc plate, and each cell is nearly filled with water.

The action of this battery is in every respect the same as that of the other form of Leclanché battery. This battery has been recently introduced, and is found to be very effective.

THE BICHROMATE BATTERY.

Mr. John Fuller has recently made a further step in advance in the introduction of a very powerful battery called the Bichromate battery. Each cell consists of a glass or stoneware jar, either of a quart size or of the same size and pattern as that used for the U K form of Daniell's battery. Inside this jar is placed a porous pot; the zinc is placed in the porous pot, and the negative plate, which is of carbon, is placed in the outer jar; the zinc is a small block of a pyramid shape, fixed at the end of a stout copper wire, both being well amalgamated, to which the binding screw is attached. Each plate being surmounted by a terminal, any number of cells can be connected together in series.

TO CHARGE THE BATTERY.

In the outer jar are placed three ounces of bichromate of potass and four ounces (or one measure*) of sulphuric acid.

In the porous pot are placed two ounces or measures* of mercury. Both are then filled up to within two inches of the top with water. As the mixing of water with sulphuric acid produces great heat, sufficient in fact to fracture a glass jar, a better plan than placing first the sulphuric acid and then the water in the jar, is to prepare a solution of sulphuric acid in an earthen vessel beforehand, and to pour this solution into the jar. The strength used is about one part sulphuric acid to nine parts water. The acid is placed in the earthen vessel first and the water then poured in; sulphuric acid should never be poured into water.

The zinc and its copper rod is then amalgamated afresh by dipping it into mercury covered with diluted sulphuric acid, and rubbing the mercury over the metals until they are quite bright, and the terminals and contacts between the different cells are made bright and clean; the battery will then soon be ready for work.

THE ACTION OF THE BATTERY.

The sulphuric acid passes into the zinc cell, and when the plates are connected, attacks the zinc and forms sulphate of zinc, while the hydrogen reduces the bichromate of potass to a lower form, called the dichromate.† The mercury keeps the zinc perfectly amalgamated, so that no local action takes place; there is a secondary action in the battery when the solutions become saturated, which results in the formation of beautiful dark violet crystals of "chrome-alum" on the carbon plate. This is a double salt, a sulphate of chromium and potassium.

It would naturally be thought that the copper being directly connected to the zinc rod would cause local action to be set up, but this is prevented by capillary attractions, the mercury gradually rises up from the bottom of the cell, and coats the copper wire with a thin film of mercury and dissolved zinc, wherever local action could take place.

The desiderata of any source of electricity for telegraphic purposes are, efficiency combined with durability and economy. Every battery has its own certain work to do, and it must be specially adapted for that work. Uniformity is very desirable in practice, but efficiency must never be put on one side for uniformity. Hence it is that, for certain purposes, where weak continuous currents are desired, the Daniell is incomparable, and, for other purposes, where sudden, powerful blows are needed, the Leclanché is *facile princeps*. Again, where weak insulation and long lines render working difficult, the Bichromate steps in to supply a want.

I have been surprised, on examining battery arrangements in other countries, especially in America—so enterprising and so 'cute—to see how far behind they are.

Batteries differ from each other in their electromotive force, internal resistance, economy, and constancy. They are required for giving either momentary or prolonged currents. They are required to work short or long lines. They may have comparatively little work to do, as at a small post office, or they may be hard pressed, as when twenty cells work ten distinct circuits, on what is called the "universal" plan.

Now, each battery has its distinct qualifications, and fulfils its proper duty.

The electromotive force of the ordinary Chamber and U.K. is the same, and if we take it as unity, then the Leclanché is 1·4 and the Bichromate 2—that is, 10 Bichromates, 14·5 Leclanché's, and 20 Daniell's have the same electromotive force.

The resistances of the forms in ordinary use are as follows :—

	Ohms.
Ordinary	10
Chambers	6
U.K.	4
Leclanché	.3
Bichromate	2

The constancy of the three forms of Daniell is, for any reasonable period, perfect—that is, a current of exactly the same strength can be maintained from them for hours, or even days. But the Bichromate is not so steady, and the Leclanché is very

* From the *Journal of the Society of Arts* for October, 1879.

* Measures are supplied for this purpose.

† This is an error. The salt is reduced to *chrome alum*, as subsequently mentioned. The bichromate of potash is sometimes called dichromate.—ED. *E.*

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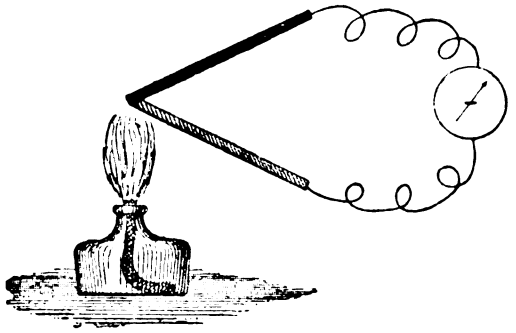
variable indeed; hence the latter can only be employed where momentary currents are used. The cost of the maintenance of the batteries just mentioned is shown by the following table:—

	s.	d.	
Leclanché	0	4	per cell per annum.
Ordinary Daniell	0	6	,, ,,
Chamber ,,	1	0	,, ,,
U.K.	1	1	,, ,,
Bichromate	1	0	,, ,,

The relative cost is, however, different, for, owing to the greater electromotive force of the Bichromate and Leclanché, a fewer number of cells are required to do the work. Indeed, one-third of the number of Daniell's cells are all that are needed of Bichromates, and two-thirds of Leclanché's.

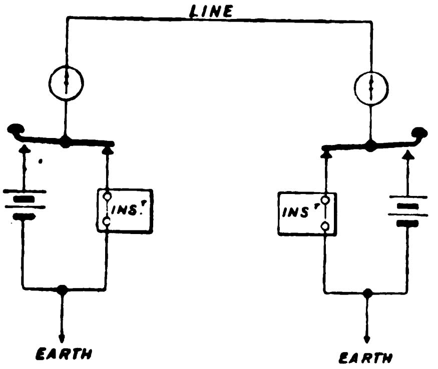
There are now in use at the Central Telegraph Station of the General Post Office the following number of cells of the various kinds mentioned:—Bichromates, 1,650; U.K.'s, 2,450; Chambers, 12,750; ordinary Daniell's, 500; Leclanché's, 500; or, say, about 18,000 in all.

There are other sources of electricity besides chemical action which are available to the telegraphist. Heat, for instance, becomes readily converted to electricity. Seebeck discovered, in 1821, that if two dissimilar metals be connected together, and heat be applied to their point of junction, a current will flow (Fig. 1), very weak, it is true, but subsequent investigators have



shown that if many of these couples be formed, and the most suitable metals or alloys be used, currents can be produced powerful enough to work telegraphs. Thus Clamond, by using an alloy of antimony and zinc for the negative metal and tinned sheet iron for the positive one, produced a pile of considerable power. It was heated by an ordinary Bunsen flame, but coke and charcoal have been used. Many were tried at the Post Office, but they all failed after constant use, and experiments in this direction have ceased.

The most promising source of electricity, where steam or water power is abundant, is the dynamo machine, so prominent just now for electric lighting purposes. Here we have the direct conversion of motion into electricity. Faraday showed, in 1831, that the mere motion of a closed conductor in the field of a magnet produced a current of electricity, and Wilde, Gramme, Siemens, and others have recently utilised this principle to produce machines of great power.

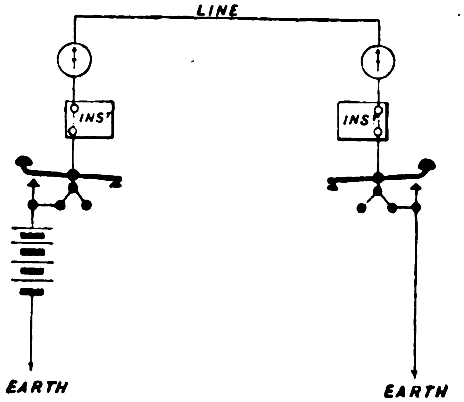


OPEN CIRCUIT
FIG. 2.

I have a small Gramme machine here, which will illustrate to you this mode of generating electricity, but no experiments on any large scale for telegraphic purposes have as yet been attempted with it. The scarcity and expense of these machines have prevented this, while their prospective value for telegraphic purposes scarcely justifies much expenditure. The principle is used on a small scale with Wheatstone's A B C telegraph, and it will be fully described when that apparatus is explained.

A few words must be said, in conclusion, about the economical application of currents, or arrangement of batteries.

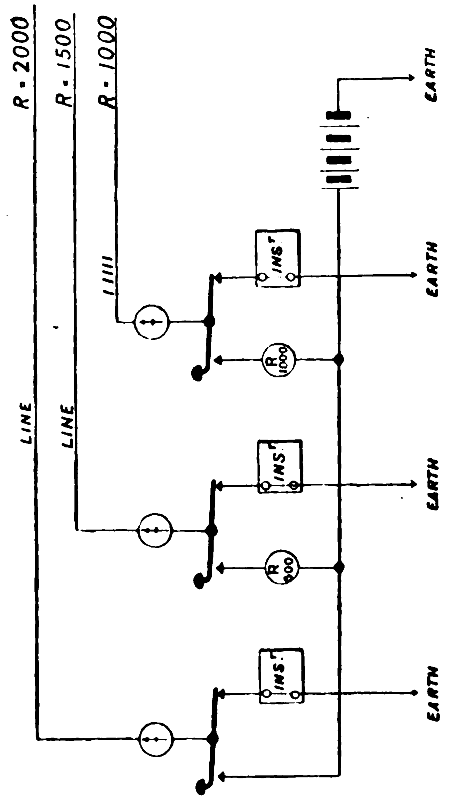
Batteries can be fitted up either on the open (Fig. 2) or closed circuit (Fig. 3). In the former no current flows except when it



CLOSED CIRCUIT

is wanted to make signals; in the latter, the current is always flowing, except when it is broken to indicate signals.* There is a combination of the two, by which the current is usually flowing; but it is broken for the purpose of signalling, each signal being made by its being completed again. The closed circuit requires only one battery, and that may be at one place only. Hence, if there be many stations on one wire, it would appear economical to use the closed circuit. But the waste is considerable, and the number of cells needed much greater at the one station. Practical experience, the true test of such a question, has effectually solved it for England, and has shown that the open circuit is decidedly the superior. In America, the closed is almost universally used.

The "universal" plan of working many circuits from one battery has already been alluded to (Fig. 4). This is a very



UNIVERSAL BATTERY SYSTEM

economical mode of working. When a battery possesses low internal resistance and considerable electromotive force, it is just as easy to work ten or twenty circuits from it as one or two. Experience has, however, taught us that it is not advisable to group circuits together for this mode of working, in greater numbers than five, and it is also advisable, in case of failure, never to have less than two distinct sets of batteries at one

* There is obviously an error in the diagram illustrating this system. The battery and earth contact should be connected to the back stops of the keys respectively.—ED. *E.*

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station. This mode of working is very general in America, and has been frequently attempted on a small scale in England, but lately it has been very extensively adopted throughout the postal telegraph system, and the economy effected thereby has been very considerable. Moreover, the probability is that the result is beneficial, because it ensures batteries of great power and low resistance being maintained in a very high state of efficiency.

It is hoped that at the next meeting it will be possible to explain how it is that the currents produced from these batteries are conveyed from place to place, to produce those electric signals that enable us to reproduce speech or language.

CABLE REPAIRING TWENTY-FOUR YEARS AGO IN A DUTCH SCHUYT.

BY F. C. WEBB.

The process of repairing submarine telegraph cables is even now often tedious and trying, but twenty-four years ago we had sometimes to rough it more even than at present. At that time I had charge of the cables between Orfordness in Suffolk, and Schweningen in Holland. These were the first cables ever repaired, and as we had no previous experience to guide us, we had to design our machinery and mature our plans as the various difficulties arose, and it was anxious and arduous work at times. Dark nights and heavy tides, with the cable at the bows, the wind rising, and the sea making it more pleasant work; but in those days we had not quite the same facilities as now, though it is astonishing what little improvement has been made in the process since the first few years of experience. But I am not about to describe cable repairing in detail, but only the particulars of a three months' work in a Dutch schuyt, as the experience was peculiar.

There were four cables between Orfordness and Schweningen, and the shore ends consisted of seven strands of cable similar to the four deep-sea cables, twisted, or, as it is termed, "layed up" together. The shore end extended for three miles from the English and two miles from the Dutch coast. The four deep-sea cables were spliced on to four of the component cables or strands of these cables, and the other spare three strands terminated in separate lengths long enough to reach to the surface of the sea. These were attached by a chain to a heavy sinker, which again was attached by a chain to a permanent iron buoy. Thus, if at any time it was required to lay another cable across, instead of having to deal with the difficulties of landing the end through the surf, it was only necessary to raise the buoy, sinker, and tail ends, and splice the cable to be paid out into one of these.

The four main cables were of too light a pattern for the locality, for ships and fishing vessels used to break them at all distances from the shore, and I had to repair them, an operation which had never been done before. At first I went out in tugs hired from London, but at last a paddle-wheel steamer of some 500 tons was fitted up with machinery, and constantly employed under me at the work. This steamer, the Monarch, was the first repairing ship. One winter (1855) one of the cables had broken down near the coast of Holland. Electrical tests made the break about ten or fifteen miles off. We proceeded in the Monarch towards the coast, but the ship's boilers were leaky, and in a gale of wind with hail on the 9th of November we steamed back to Lowestoft. As the ship's boilers proved to be in a very bad condition, it was determined not to send the ship to sea that winter, but to attempt to repair the cable in a Dutch "schuyt," the flat-bottomed fishing vessels which sail from the sandy beach of Schweningen. I was accordingly ordered to take the captain and six sailors from our ship, and proceed to Holland to attempt the repair of the cable in this novel way. We took a few ropes, grapnels, sheaves, tools, and 300 yards of telegraph cable, and arrived there on Dec. 8th.

Schweningen is, or was then, only a small village, with a large hotel for summer visitors, a church, and 112 of these flat-bottomed schuyts. There is no harbour, bay, or shelter of any kind. The coast, formed of a low sandy beach and sand hills, is perfectly straight so far as the eye can reach in either direction. As you stand on the shore, facing the sea, in front of the hotel, if you turn to the right a dismal perspective of straight sandy beach and sand hills vanishes in the distance, and if you turn to the left exactly the same picture reversed, plus a very plain lighthouse, meets the eye. The church and hotel are the only objects that could be seen from the beach at all, for the village is hid is by the sand hills.

The schuyts themselves, with their bluff bows, quaint-shaped sails, big dog vanes, leeboards, and broad streaks of gaudy colour are picturesque enough, and when some of them are being dragged down to the beach on rollers by twenty or thirty horses, whilst others are just beaching through the surf, and a sale of fish is going on, with a crowd of fishwomen and fishermen, the scene is curious and picturesque, and indeed many of our best marine artists have chosen Schweningen and its schuyts as subjects for their brushes. But this is all in summer. In winter the 112 schuyts are hauled up high and dry, their masts lowered, and in fact the whole craft housed. The beach and sea are quite deserted, and with snow covering everything, a more dismal, cheerless place, can hardly be imagined.

The hotel, too, the great hotel of Mr. Maas, in which I had to stay without any other companion than the captain of the Monarch—oh, how doleful it was. A great place, with immense *table d'hôte* rooms, in which hundreds of chairs were piled up on the tables, and long sanded corridors in which one's steps re-echoed in dismal solitude, and hosts of unoccupied rooms, for we were absolutely and entirely the sole occupants of this great summer palace, with the exception of the landlord and his family, who lived far away in another direction, and on a different floor to us, and to find whom one ran the risk of getting lost altogether.

Our plan was to hire a schuyt, and attempt at any intervals of fine weather to go out and get hold of the faulty cable at the buoy on shore end, and underrun it by hauling the schuyt along the cable until we came to the broken end, which we should buoy, and then grapple for the other end.

At first no schuyt owner would attempt the job at this time of year, but at last the landlord of the hotel who was also a kind of Nabob of the village and general arbitrator over fishermen, got a crew for his own schuyt, which was chartered by us at a liberal price. These craft are 34 feet long 17 feet beam, so that they are just half as broad as their length, a proportion that would not suit the designers of one of "Bibby's streaks." They are clinker built, that is, each plank overlaps the other, and rivetted together by copper rivets. The way of building is very peculiar, the whole of the outside planking is put together first, and the ribs and beams are added afterwards.

The bottom is very strong—a solid platform of timber—but the sides are only about three-quarters of an inch thick. The bows are nearly square, and may be said, indeed, positively to re-enter near the head knee or cutwater. They are, in fact, nearly boxes. They draw about two feet six inches or three feet, and have no keel, and would go to leeward like a haystack when sailing in a wind if it were not for the huge leeboards which they carry on each side, the lee one being, of course, lowered when sailing by the wind.

We got our gear on board, and went to sea for the first time on December 12. We were nine Englishmen and seven Dutchmen. That part inside of the schuyt where I was installed with the English and Dutch captains, and some of the Dutch sailors, was a most curious locality. It was in the fore part of the ship, and on each side was a broad bunk, wide enough for two to sleep abreast, and covered with straw in the centre, and forward was the fire place, square and built of brick, strapped with iron, something like a blacksmith's forge, and with a square sloping cowl of boarding over it, tapering up to the square wooden funnel on deck. On this structure peat was burnt, and oh! the smell in that place from the burning peat, added to the stale smell of fish, the frying of bacon, &c.

The process of getting to sea is peculiar. The craft is dragged down on rollers to near low water mark, and then (if the schuyt has not been to sea lately, and has no grapnel already lying seawards) a tall man who makes his living by it carries the grapnel out on his shoulders as far as he can reach, and throws it down, the grapnel, of course, having a hemp cable fast to it. This is taken to the capstan, and hove taut. As the water rises the seas roll in against her bluff bows, and thumps against them with a crash, and as she begins to float she bumps on the beach with a terrible thwack that makes the beams dance up and down as if the whole thing was coming to pieces. The men heave at each rise on the capstan shortening and gaining only a few inches on the heavily strained cable, the clatter of the palls of the capstan lasting only for a minute. The seas break against the bows with greater fury, and the craft strikes heavier, but less frequently, until at last, after about an hour, she suddenly ceases to strike at all, the palls of the capstan clatter continuously as the men, cheering, run the capstan round, taking in the slack rope as the ship, no longer held by the ground, has sprung forward to the highly strained cable. Then, as the tide generally runs along the coast, and we can only get off with the wind along the land, she begins to swing broadside to the sea. And then the quick, sharp rolling of this flat-bottomed craft gives a fearful trial to one's patience and stomach. Enured as we all were to the sea, to ships, steamers, fishing-boats, &c., yet none of us had before felt this peculiar motion, and all but one of us nine Englishmen were miserably sea-sick. The one that stood it was "big Jim" Elrish, afterwards captain of the Monarch. At first, too, the motion was so strange that we could not walk without holding on, as the bulwarks were only about nine inches high—just enough to trip a person up and drop them overboard.

[TO BE CONTINUED.

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TECHNICAL EXAMINATIONS.

An involuntary listener in a first class carriage of the South Eastern Railway, hearing the rehearsal of parts by two amateur actors, was vividly impressed with the fact so often stated, that one finds little difficulty in learning, when interest is excited, and the heart is in the work. Dr. Carpenter startled a good many steady-going people with a lecture on the question, Is Man an Automaton? We might slightly vary the question, and ask if the ordinary mechanic is an automaton? Does the youthful learner of a trade put his heart into his work? Is he satisfied in jogging along day after day like a machine, doing what he is told, letting his intellect rust from the want of usage, and growing up a dexterous machine? Has he any desire to excel, or is he willing to come and go as the bell rings, to take his thirty shillings or two pounds a week, spending all as fast as it comes, and dying in the workhouse? These and a dozen other questions flash across our minds when we think of the present position of England. Have we still that pride among the majority of us that, although our work may satisfy others, it does not satisfy ourselves; do we see faults of detail, do we see where improvement can be made, and have we the determination to mend the faults and make the improvements? Questions are easily asked, but answers are not so easily given. Sometimes our study of "man" leads us to hope for a bright and brilliant future for this island of ours, then another phase of human life presents itself, and our hopes subside, leaving behind but few rays of sunshine. On the whole, however, we think that progress is indicated, and that our motto may still be onwards and upwards. One of the brightest pages in the history of the Nineteenth Century will be its history of education. In the early part of the century a village school was almost unknown, but scarcely had the first quarter passed away before the thinkers had carried their point, and the religious sects commenced energetically to carry out the important work. The opposition of Church and Dissent was a blessing; emulation in this case was good. The Press was unshackled, and brains hitherto lying fallow came into use. The result was seen in every direction, and will be acknowledged by all who devote a short time to the consideration of the progress of steam, machinery, and electricity. The study of science became more general, travel enlarged the mind, and men wondered why the world had slumbered so long. Another dawning, and it was seen that an engineer was not only born but must be educated. The eating of three dinners did not make a lawyer, nor the study of Latin and Greek an electrician. Technical instruction was introduced into schools and colleges. The Government instituted a department to assist in the work, and quite recently the City Guilds have stepped in to take a share in the labour.

It cannot be any other than a good sign when thousands upon thousands of young men are found willing to devote their evenings to the learning of the theory of their craft, while their days are occupied in its practice. Many of these students, no doubt, attend classes from other reasons than the desire to know all about their work and to excel in the business they have entered; but we fancy the majority must have the right feeling, or they would not give up so much of their spare time. The institution of the Whitworth scholarships—the goal of science students—again has acted as an incentive to hundreds to cultivate their brains, and although the successful candidates are not numerous, the unsuccessful must have benefited by their studies.

The examinations of the Science Department are far from perfect, they have been formulated by theorists who have not, and cannot, have any real conception of the wants of the workshop. We know that it was possible a few years ago to obtain first class certificates in the advanced stage of electricity and magnetism, without the slightest practical knowledge, without having seen a Wheatstone Bridge, or a telegraph instrument of any kind, or a magnetic machine of any kind. A smattering of book knowledge sufficed to enable one to answer all the questions proposed, and it was painfully evident that the questions had scarcely any bearing upon practical work. We are not sure that during the early years of these examinations such a system was altogether bad, inasmuch as, if the questions had been rigidly of a very practical kind, few students would have been found to trouble themselves about the study of the

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subject. Large numbers, doubtless tempted by the seeming ease of the examination, had dabbled in the study, and many of these, like the amateur actors becoming interested in their work, have pursued the subject, and are now capable electricians. Latterly we notice a gradual alteration in the tone of these examinations, and we trust that, ere many more have been held, they will have a still more practical character.

With regard to the City Guilds Examinations, we have carefully read the programme, and find that in many cases the examiners are probably the best that could be selected, having not only a thorough theoretical, but as thorough a practical grasp of the subject. In some subjects, a pure theorist has been selected, and the result is seen in the examination paper consisting wholly of theory, without a question testing the ability of the candidate to apply his theory in practice. The great feature of the Guilds' action is the inauguration of a system of lectures. Without teachers it is difficult for a student to do good work, he wastes much valuable time, and, relying on himself, his energies are too frequently misdirected. Science teachers in connection with the Science Department have done certain work, but many of them are themselves merely students of the elementary branches of the subjects, but the City Guilds have, as a commencement, selected two of the ablest teachers, viz., Dr. H. Armstrong, F.R.S., for Chemistry, and Professor W. E. Ayrton for Physics, to give courses of lectures at the Middle Class Schools, Cowper-street. The syllabus of Professor Ayrton's first course is before us, and it deals with electrical subjects. We were struck with the able manner in which Professor Ayrton last session described the researches of himself and Professor Perry to the Society of Telegraph Engineers, and there is no doubt his large experience in teaching will enable him to put his subject clearly before the students who attend these lectures. Intensely interested in the subject himself, we trust he will be able to create an interest in electrical studies among a large number of young men who have hitherto looked upon all such studies as part of a duty, and nothing more.

THE ELECTRIC LIGHT AT THE BRITISH MUSEUM.

On Monday, the 20th, the reading room of the British Museum was lit up by the electric light, and was visited by representatives of the Press and various gentlemen connected with electrical engineering. The work has been carried out by Messrs. Siemens Brothers. The proposal for lighting the room was made to the secretary by Messrs. J. J. Calder and J. A. Barrett, electricians of some experience in submarine telegraphy. The proposal met with every encouragement by Mr. E. A. Bond, the principal librarian and secretary; and the arrangements of Mr. Siemens and of Messrs. Wallis and Steevens, the engineers who supplied the engines, were carried out under the superintendence of Mr. Barrett, who is now acting electrician to the Museum.

The lights in the reading room, though a little unsteady when looked at direct, were sufficiently steady to read and write by, and, indeed, we wrote these notes with perfect comfort. It is proposed to keep the reading room open until six p.m. throughout the winter.

Two different systems of electric lighting are employed, the reading room itself being lighted by four lights of 5,000 candle power each, produced by continuous currents, and the seven 400-candle lights, which are distributed over the entrance halls and the outside of the museum, being connected in one circuit of about 1,200 yards length to an alternate current machine.

The regulators in the reading room are the invention of Messrs. Siemens and Halske, of Berlin, and are of a very simple construction, so that they can be easily managed even by inexperienced hands. As they are constructed to take carbons nineteen inches long, and as these are consumed at the rate of nearly three inches per hour, the light can be maintained for about six hours without the regulators being touched.

For the alternate currents, other regulators are employed, which are actuated by two solenoids on a differential principle, one solenoid forming part of the main circuit, and tending to separate the carbons, the other forming a shunt round the carbons, and tending to bring them together. The position of the carbons depends, therefore, not on the strength of the current, but on the relative amount of electricity passing through each solenoid. By choosing suitable resistances for each coil, an arc of a given resistance will always be maintained, independently of the strength of current, so that the necessity is obviated of regulation after the lamps have left the hands of the makers.

These regulators are also so arranged that the going out of one, say through want of carbon, does not affect the burning of the other lights in the same circuit, and new carbons can be put in such a lamp in about half a minute, when it is ready to burn for another five hours.

The machines which supply electricity for the lights are placed in a shed behind the Museum.

The leading wires from the machines to the lights in the reading room are brought over the roof of the buildings to the lantern on the top of the dome, being a distance of about 200 yards; whereas the leads for the other lights are laid partly in the basement and partly in pipes underground.

The machines are six in number, five of them are Siemens medium single current machines, four of them being used for the four lights in the reading room, and one to excite the magnets of these four. It is considered by this means that greater steadiness is obtained. A sixth machine is an alternating current machine, and works the seven lights in corridors and outside, &c.

The machines are worked at about 650 revolutions per minute.

DESCRIPTION OF ENGINES BY THE PROPRIETORS.

The motive power is supplied by two eight-horse semi-fixed engines, constructed by Messrs. Wallis and Steevens of the North Hants Iron Works, Basingstoke. These engines possess some special features which render them peculiarly adapted for driving electric lighting apparatus, foremost among which is the regularity of speed maintained by the governors with which they are fitted, which are of the cross-armed, central-weighted type, and extremely sensitive. This point—viz., *uniform speed* is of the utmost importance in electric lighting, as any variation causes a corresponding unsteadiness in the light. We understand that Messrs. Wallis and Steevens have just patented a new arrangement which will enable the governors to maintain *any particular rate of speed* that may be desired, the adjustment being made gradually and without stopping the engine. The engines at the British Museum are not yet fitted with this arrangement, but will be as soon as it has been thoroughly tested at the works at Basingstoke. The makers inform us that they entertain no doubt whatever that it will entirely fulfil the conditions so much desired by electricians—viz., the power to increase or diminish the the normal speed of the engine at pleasure according as the lights require it, and then to maintain with perfect regularity the *particular* speed which is found to give the best light. The engines are, as previously stated, each of eight-horse nominal power, but can, if required, be worked up to nearly three times their nominal power. The cylinders are 9¾in. diameter, and the length of stroke is 12in. Their normal speed at present is 125 revolutions per minute, but the governors are fitted with change pulleys, so that by stopping for a minute or two to change the pulley the speed can be either 125, 130, or 135 at pleasure. It is to do away with the necessity of stopping the engine to make the change, and also to give a much wider range of adjustment, that Messrs. Wallis and Steevens have contrived the new arrangement previously alluded to. The cylinders are steam jacketed on Messrs. Wallis and Steevens's improved plan of making the jacket and liner separate, and fitting the liner into the jacket. The boilers have been tested by hydraulic pressure to 150lb. per square inch, viz., double the highest *working* pressure of 75lb. to the inch. The fire-grate area is six square feet, and the the heating surface 165 square feet. The engines are fitted with the makers' now well known patent annular space feed water heater, which delivers the feed water into the boiler at a temperature of about 205 degrees. The special features of this heater are, that the exhaust steam is not *mixed* with the feed water; that the water is heated *after* passing through the pump, thereby getting rid of the difficulty of pumping very hot water; and that the whole of the heating surface over which the feed water passes can be exposed for cleaning in less than five minutes by the removal of two small covers. The power is transmitted from the engines to the dynamo-electric machines in the following manner:—Across the machine room runs a countershaft, on which are fixed two pulleys or drums, each of which is driven by a belt from the fly wheel of one of the engines. On this countershaft are placed seven other pulleys, from which belts transmit the motion to the five dynamo-electric machines, which work the lights in the reading room, and to the exciting and

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alternating current machines, by which the other seven lights are worked, these last seven lights being all in one circuit. The whole of the arrangements seemed to answer very well, and the lights seemed to be ample for the purpose, and were fairly steady, but it is believed that even the little unsteadiness will be ultimately eliminated. The work requires considerable skill in the arrangements, and these reflect great credit on Mr. Alexander Siemens, who has had the practical supervision of the whole work. To Messrs. Calder and Barrett, who took the initiative in bringing the matter before the authorities, credit is also due; as well as to Messrs. Wallis and Steevens, who supplied the excellent engines.

EDISON'S ELECTRICAL GENERATOR.

The following is given on the authority of the *Scientific American*:—

When Mr. Edison said he was about to produce a practical economical electrical light for general use, the entire business world took it for granted that it was forthcoming. Gas stocks tumbled both in this country and in Europe, and the people waited for the coming light. Scientists having had experience in this direction shook their heads, but for the most part suspended judgment.

Delay on the part of Mr. Edison comforted the holders of gas stocks, and confirmed the scientists in their belief that he had undertaken not only a task of great magnitude and difficulty, but one that would require more time and means than could be controlled by most experimenters. But Mr. Edison, flushed by his scientific victories, was undaunted and determined to yield to no obstacles.

Unfortunately, however, the daily papers from time to time printed reports of progress in electric lighting, which, from their extravagance and inaccuracy, placed Mr. Edison, to say the least, in an extremely embarrassing position as regards his alleged promises and the expected fulfilment of them, besides misleading the public as to the true nature of the problem to be dealt with, resulting in a reaction of feeling prejudicial to Mr. Edison's just fame.

At present little is said by Mr. Edison concerning his electric light, excepting that he considers it an assured success, and that he is perfecting the details of his electric lighting system as rapidly as possible.

It is not our purpose just now to enter into a description of Mr. Edison's electric lighting system as a whole, but to describe his new electric generator—one of the most important factors of the system—and also to describe his new electrical motor used in driving light machinery for domestic and industrial purposes.

The new generator resembles in some respects other well known forms, but it differs from them all in several very important particulars; for instance, the field magnets are immense, being about 54 inches high, and weighing about 1,100lb. The magnet cores—of wrought iron—are 6 inches in diameter, and 36 inches long; they are mounted upon heavy cast iron blocks, $10\frac{3}{4}$ inches high and 9 inches wide, and are connected at the top by a wrought iron yoke, 6 inches high and 7 inches wide. The cores are wound with three layers of No. 10 cotton covered wire, the ends of which are connected with binding posts on the base of the machine. The two blocks upon which the cores rest, as well as the bearings of the armature, are supported by a cross-shaped brass casting.

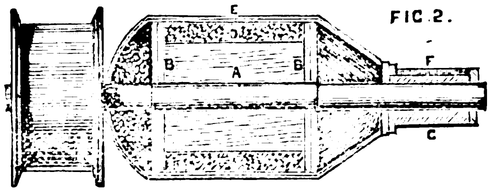

FIG. 2.

The armature which revolves in the cylindrical space between the poles of the field magnet is shown in section in Fig. 2. It consists of a wooden cylinder, A, mounted on a $1\frac{1}{2}$in. shaft, and having attached to its ends soft iron plates, B, between which there are several layers, D, of No. 20 soft iron wire wound circumferentially. Outside of the iron discs, B, there are vulcanised-fibre discs, C, having their peripheries notched to receive the several coils, E, of insulated wire wound lengthwise on the cylinder and connected with copper bars, F, of the commutator cylinder, G. There are 41 $\frac{42}{1000}$in. wires in each strand, and each strand passes lengthwise around the cylinder on diametrically opposite sides, the opposite ends of all of the wires in each strand being soldered to commutator bars on opposite sides of the commutator cylinder. There are 40 strands surrounding the armature, and the commutator cylinder is pressed on opposite sides by copper wire brushes which take off the current. The armature shaft has a 10in. pulley with a 5in. face, and the speed of the machine is about 500 turns per minute. Although the current from the armature may be used to excite the field magnet, Mr. Edison finds it more economical to charge the field magnet by means of a separate machine. In fact, he intends to charge a battery of such generators with a single Faradic machine of this form.

An important fact has been developed in the course of Mr. Edison's experiments with this generator. He finds that by connecting the ends of the field magnet by a copper wire for a moment when the machine is started the field magnet soon attains its maximum charge, which it retains so long as the generator is in continuous operation. It requires a minute or more to fully charge the immense magnets, and when charged their influence is far reaching and powerful. The internal resistance of the armature is only $\frac{1}{2}$ ohm, and Mr Edison claims that he realises 90 per cent. of the power applied to this machine in effective external current. It requires but 5 horse-power to drive it, and the current generated is sufficient to make 40 lights of 16 candles each. The economy of this machine is shown by the fact that one man may turn it with sufficient rapidity to maintain the electric arc of a Jablochkoff candle.

While this generator in general principle is the same as in the best of the well-known forms, still there is an all-important difference, which is, that it will convert and deliver for useful work nearly double the foot-pounds of energy that any other machine will under like conditions. It has been shown by Hopkinson that the Siemens machine, which is generally recognised as the best form yet devised, converts from the belt to the circuit 92 per cent. of the energy, but later corrections reduce this to 83 per cent; from these results many scientists have inferred and stated that there was little margin for improvement in the generating machine. Now the energy converted is distributed over the whole resistance; hence if the resistance of the machine be represented by 1, and the exterior circuit by 9, then of the total energy converted, $\frac{9}{10}$ will be useful, as it is outside of the machine, and $\frac{1}{10}$ lost in the resistance of the machine.

The Siemens machine, and nearly all other machines in use, make the external resistance equal to that of the machine; hence one-half of the energy only is useful, and any attempt by these inventors to increase the exterior resistance, so as to change the distribution of energy to obtain more exterior work, results in reducing the power of the machine to convert energy. Therefore, efforts toward economy in one direction are met in the other direction by loss in the interest account due to the necessity of using a greater number of machines to convert a given amount of power.

In Mr. Edison's generator 5 horse-power is transferred upon a resistance of 5 ohms, of which a $\frac{1}{2}$ ohm is in the machine, thus delivering $\frac{9}{10}$ of the total current upon a circuit exterior to the machine; thus nearly the maximum economy is attained when other machines, under like conditions, will scarcely give any current at all.

In dealing with the electric light problem, Mr. Edison has very properly devoted a large share of time and attention to the production of an economical generator, as it is the very foundation of the system. It bears the same relation to electric lighting that the cheap production of gas does to gas lighting. It is as important to generate electricity cheaply as to use it economically. Mr. Edison meets squarely both ends of the question, and is carrying on his experiments on a gigantic scale; being encouraged by new developments he continues his researches in expectation of still better things. His electric generator he considers complete; his electric lamp, although in good usable form, is slowly improving, and will not be introduced to the public so long as Mr. Edison thinks it can be improved.

The lower view in our large engraving represents one end of the Menlo Park machine shop, showing the 80 horse-power engine in the engine room beyond. One of the new electric generators is shown on the right, and the dynamometer with which the power tests are made is shown on the left. Not far from the generator is placed an electric dynamometer, shown in one of the smaller views at the top of the page.

This electrical dynamometer is the invention of Prof. J. W. Trowbridge. Mr. Edison has, however, improved it and adapted it to his own purposes. As there is neither iron nor magnets in the apparatus it may be used in the vicinity of the generator without being influenced by its magnets.

The electrical current traverses the two large spirals of copper ribbon, and also the smaller spiral, whose bifilar suspension keeps it at right angles to the larger spirals when no current passes. The smaller spiral carries a small mirror, and the readings are taken from a distant scale, the light spot serving

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as an index. The circuit is completed through the smaller spiral by means of mercury cups kept cool by water running through their hollow walls.

The galvanometer tests are made in a distant building where neither jars nor magnetic influence can affect the accuracy of the readings. The galvanometer (Thomson's reflecting) is placed on a table resting on a brick foundation, and is enclosed by a dark chamber having apertures for viewing the scale. The development of the new electric generator has required months of careful investigation by aid of these two instruments, and it is only after making hundreds of alterations and experiments that the improvement has been wrought.

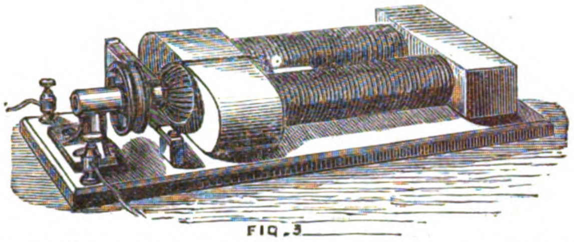

FIG. 3

Fig. 3 shows Mr. Edison's new electric motor intended for running sewing machines, small elevators, lathes, and other light machinery, by connecting it with the same wires that furnish the current for the electric lamps. Its construction differs but slightly from the electric generator. The armature is arranged parallel with the magnet instead of transversely, and the magnet is formed of a single casting. In other respects it is like the generator, having the same form of armature, also commutator cylinder and brushes. The engraving represents the motor about one fourth of its real size.

Whatever may be said or thought in regard to Mr. Edison's progress in electric lighting it cannot be denied that he has made important discoveries which must tend to cheapen the electric light generally; and when he shall have completed his electric lighting system we hope he will reap the reward merited by his untiring perseverance.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

The twelfth ordinary general meeting of the shareholders of this Company was held on Wednesday, October 22, at the City Terminus Hotel, under the presidency of Mr. J. Pender, M.P.

The CHAIRMAN said: Gentlemen, the Secretary will read the notice convening the meeting.

The SECRETARY read the notice convening the meeting, and the minutes of the meeting held on the 7th of April.

The CHAIRMAN: Gentlemen, is it your pleasure that these minutes be signed? Those of that opinion say "aye." To the contrary. Having signed the minutes, he said: Gentlemen, I presume that you will take the report as read? [hear, hear]. [The report appeared in *The Electrician* of last week.] Continuing, the Chairman said: Then before putting the resolution to the meeting for its adoption, I will, as usual, give you a few figures on the working of our system. As stated in the report, the gross receipts for the half year ending the 30th of June, 1879, were £150,107 against, for the corresponding period of 1878, £135,482, showing an increase of £14,624. The expenses for the past half year amounted to £65,509 against, for the corresponding period of 1878, £61,222, or an increase of £4,287. This is more than covered by the expenses of keeping three repairing vessels during the last half year instead of two, as in the corresponding period of 1878, and by carrying an additional £1,000 to the maintenance ships' reserve fund. But for this a saving of about £2,300 would have been shown. The screw steamer, Edinburgh, has now, however, been sold, as stated in the report, for £10,000. The net revenue for the half year under review was £84,597, in the corresponding period it was £74,260, being an increase of £10,337. Two interim dividends of 1¼ per cent. each, absorbing £49,937 10s., have been paid for the half year, leaving a balance of £34,660 to be carried forward. As to the duplicate Australian cable, the first section of it was successfully laid and opened for traffic on the 16th August last, and connected Malacca. This was done by arrangement with the Government of the Straits Settlements, who have to pay the Company an annual subsidy of £1,000 for ten years. A considerable portion of the second section between Singapore and Java has been laid, and a vessel with the necessary cable to complete the section is now on her way to Singapore. We anticipate that the contractors will complete the whole work in the early part of next year. The articles of association state that in case of a vacancy in the auditorship it shall be filled up by an extraordinary general meeting. As, however, Mr. Ball's death took place so recently, the directors considered it unnecessary to call a meeting specially for the appointment of a successor, and, therefore, requested Mr. Ball's firm to complete the audit to the 30th of June. The vacancy will be filled up at the extraordinary meeting which is to be held at the conclusion of this meeting. Now, gentlemen, I have given you certain figures, or rather made certain comments, upon the report which you have in your hands. I may now say a few words, and those of congratulation, on the general improvement of our traffic. I have stated that up to the end of the half-year ending 30th June last we have shown a net profit over the corresponding period of the previous year of £10,000. From that time up to the present I am glad to say that our traffic has generally been very successful indeed—in fact, I may say that we are having now the best traffics we have ever had, and this may be to a certain extent accounted for in two ways. There is the Exhibition going on at Sydney for the present month, and there is a general improvement in trade. I have very often said at these meetings that our telegraph system is a very good barometer of trade. With bad trade we suffer, with good trade it is quite remarkable the buoyancy that takes place, and I hope that the improvement which is now pretty well acknowledged to exist will be maintained. You know that we have always been told that any improvement was to come from America. Well, America is very rampant at the present moment, and that is also testified by the returns on the Atlantic cable system. I have often also said that the importance of duplicating your cable was very great indeed; and I may mention that while our cable has no interruption at the present time, yet, had we not laid down our duplicate system—or that portion between Singapore and Penang—we should have been at a standstill. The original cable is now interrupted, and the whole system would have been interrupted. Fortunately this duplicate was laid down in time, and we are reaping the benefits of additional security and also of the improved traffic. I am glad also to tell you that, with regard to the duplicate cable which we are under contract to have completed by the end of February next, that we were enabled, without any loss or sacrifice on our part, with the sanction of the Australian Government, to give the home Government evidence of our desire to help them in having the Cape cable established; and I am glad to say this, notwithstanding our helping them in that object, the duplicate system will, I believe, be completed very early next year, or nearly two months before the contract time [hear, hear]. I am also glad to tell you that Colonel Glover has visited all our stations. He was absent from London for something like eighteen months, and he has been able to give us a report of the working of our system, and I am glad to say that this visit has been of very great good, as you can well conceive. Our young men like to see their managing director among them, and I believe that Colonel Glover's visit has been productive of very great good. We were also able to avail ourselves of his presence in Australia to carry to a successful issue the negotiations with the Australian Governments. To do this Colonel Glover had to get them into a spirit of harmony for the benefit of the whole, which is rather a rare thing to get done. Each thinks that he knows better than his neighbour, but in this particular business of the duplicate cable they seemed to be pretty well in accord. Colonel Glover has travelled during the time he has been away something like 40,000 miles. I am also pleased to say that up to the present time the experimental system of sheathing our cables with a brass coating has been successful. With these remarks, gentlemen, I think that I have pretty well exhausted all that I have to say to you, except this—that, as you are all aware, an important conference was recently held in London of the telegraph representatives of every Government, certainly of Europe, which laid down certain laws. We had not a seat at that conference, but so far we have always felt that we have been fairly dealt with by the conference. There is, however, a difference of opinion among some of the merchants at the present time, who think that they have been more or less aggrieved by certain alterations that have been made. But I will only make this remark—that we have no power to alter what has been done. We have certainly the power of receiving communications from merchants who feel themselves aggrieved, but I would say to those merchants that, looking to the history of submarine telegraph progress, up to the present time they have certainly had the best of it [hear, hear]. They have dealt with the code system to an extent that was never contemplated. Had the original prospectus of this company been carried out, we should have been paying you to-day probably 35 per cent. instead of 5 per cent., and, therefore, the merchants have no cause to complain. They have done all they could—they have used their utmost ingenuity. I do not blame them for this. I think it quite reasonable that they should have the greatest amount of traffic carried at the smallest expense; but, on the other hand, they must take care not to kill the goose that lays the golden eggs [hear, hear]. If any merchant feels himself aggrieved I shall be very glad to meet him and discuss the question, and I am satisfied that I will show him that the greatest benefit of the system has been with him and not with the shareholders. With these remarks I beg to move the adoption of the report. The resolution is—"That the report and accounts of the directors now submitted be received and adopted."

The Right Hon. W. N. MASSEY, M.P., the Deputy-Chairman: I beg to second that.

Mr. STOKES: Mr. Chairman and Gentlemen—It is very gratifying to me to receive so good a report, but I think that the amount carried over will admit of a bonus of ½ per cent. We are only receiving 5 per cent. I do not wish to put this as a motion, but I merely point it out for your consideration. We have gone through very bad times, and I really think that if we could now have a bonus of 2s. 6d. it would be very acceptable. I would also like to ask whether there has been any extra credit to capital on the receipt of this £10,000. If there is no extra to capital that would strengthen my argument that we are entitled to 2s. 6d. extra as a bonus.

Mr. HERSEY: In what account do we find the interest from the reserve fund?

Mr. NEWTON: As to the expenses of patents in the past half year they were £1,800, the previous half year £2,662, and in the previous half year £985. I understood you to say at the last meeting that the £2,662 was the payment for three years, not for half a year. If so how is this £1,800 double what we paid twelve months ago? As to the sale of the Edinburgh, shall we have in future accounts something like £6,000 for maintenance of ships, and at the same time carrying to reserve for ships £3,000? This seems a very large amount to have paid in maintenance of ships and to the reserve for maintenance of ships. Had there not been that expenditure I think we could have received 6 per cent. I think it would be very unadvisable to have a bonus. What we want is to get on a level of 6 per cent., and when once there let us stop there, and not have fits and starts. I think we are now very nearly approaching that.

The CHAIRMAN: As to the payment of a bonus, gentlemen, I think you will agree with me that we must see a little more prosperity. We must get out of the wood of adversity a little more before we begin to talk about being generous. What I am very anxious to see is a large increase in our reserve fund [hear, hear]. When we get a good backbone to reserve

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fund, depend on it your stock will command a better position in the market, and, having obtained that, in the future you will be able to come forward and say, "Now, with such a reserve fund I think you may fairly increase the dividend, or deal with a bonus;" but I think it is too early yet. In the first place, what we are getting now comes very much from our old system. As I mentioned, one section of the duplicate system has been opened. It has prevented us from losing traffic during the past three weeks, but we have not got any benefit yet out of the duplicated system. The additional income we have received is entirely from the improvement in trade. Now, with regard to the interest on the investments representing the reserve fund, our investments were made just at the end of the half year, so that in the next account the interest will appear. The charge for patents to which Mr. Newton refers is a fluctuating item. If our cable is broken our payment for the time being to the patentee ceases, and, therefore, if there were any continuous break he does not receive the payment. Another reason for a large amount appearing in the December accounts is that for three years we paid nothing on the New Zealand system, and, therefore, we had to pay in a lump sum what was really due to the patentee. One of these important patents falls due next year—the mirror patent—which I call the life's blood of a telegraph system; and then we shall be relieved of a considerable sum in respect of these payments——.

The CHAIRMAN: Sir James Anderson corrects me. Although the mirror patent expires, the same parties have a patent called the recorder, which we use; and while we use the recorder their patent rights continue. But I have always said to telegraph shareholders that we were anxious to encourage all scientific men in bringing about any improvement in the working of our cables. If we can get ten words instead of six, and twenty words instead of ten, it is an enormous gain looking at the first cost of a cable. Our duplex system has doubled the value of those cables by greatly increasing their working power, and, consequently, the sum we pay for duplexing the system is comparatively a small one. In short, we give every possible encouragement to scientific men, and if we show you that we have added in any one half year £500 or £600 to the expenses of patents, depend on it we have got as many thousands in return for it. As to the depreciation in the ships, any one who has anything to do with ships will back me up in saying that we cannot write them down too soon to a fair value. After a few years it is wonderful the expense you incur in keeping a ship in efficient condition, and therefore we are erring on the safe side. We are writing our property down to what I call a sound figure; we are adding largely to the reserve, and we have continued during these bad times to pay you a steady dividend of 5 per cent [cheers].

A SHAREHOLDER: Will Colonel Glover give us some little information as to his visit, and when the cable will be repaired. On one occasion I asked the question, and it was said that it would be done on a certain day, but I heard nothing further of it.

The CHAIRMAN: Well, at the end of the meeting we will consider that.

Mr. GRIFFITHS: I gather from your observations that we have lost no business from the breaking of the cable, but possibly the repairs of it may take some long time?

The CHAIRMAN: Oh, no; every hour we may hear of it. It is a small fault that we are taking out at different points.

Mr. GRIFFITHS: Then there is nothing serious?

The CHAIRMAN: No; in fact, the ships have too often been employed in those seas in dealing with the interruptions caused by the teredo. I beg now to ask you to approve the resolution. Those to the contrary. Carried unanimously. Continuing, he said: Now, gentlemen, that closes the business of the ordinary meeting, and I have now to draw your attention to the business of the extraordinary meeting, and the resolution I have to ask you to approve to-day is one affecting what I would call an additional arm to our system. At the present moment there is no cable, as you know, between Hong Kong and Manila. The Spanish Government have, I think, on two or three different occasions granted concessions, which have never been carried out. The Telegraph Construction Company some time ago, when the Spanish Government asked for tenders, offered to make this cable. They got the concession, which, I may say, was principally due to our co-operating with them, on conditions I shall state. Having a system up to Hong Kong, the Spanish Government saw it was of great importance that the Manila cable should be connected with our system, to give communication with the whole world; and therefore the Telegraph Construction Company were enabled to secure this concession. We had arranged with that Company to take over this concession on certain terms. The concession has been granted, but there are some points in it which we are not satisfied with, and which we wish to have adjusted. The representative of the Telegraph Construction Company is now in Madrid with the view of getting these arranged, which we think it necessary to obtain before we have anything definite to do with it. These being obtained, I think it a very important link in our system, and I therefore ask you to day to empower us to deal with the Telegraph Construction Company for the cable when it is laid and completed. I may say a few words and give you a few figures as to what advantage it will be to us. The distance to Hong Kong is 555 knots, and the capital required is about £120,000. The contractors are prepared to take debentures for £100,000, and we propose to pay out of our reserve fund the balance of £20,000. The interest on that will be considered as is an investment in any other way. We are to get from the Spanish Government a subsidy for ten years of £9,600 a year. The estimated traffic—what we conceive will be the traffic added to that—will be £10,879, giving us a gross receipt of £20,000. The working expenses and interest on capital together will be £8,300, and that gives us £12,179—say £12,000—or 10 per cent. on the capital, which, invested at 4 per cent., would in ten years realise £140,000, so in ten years we shall have the cable for nothing. We shall benefit our present system by the increased traffic, and we shall keep in our own circle this line, which, if it had got into other hands, would have caused what I believe is always destructive to telegraph interests—hostile competition. I think with these remarks you will see that the proposal for acquiring this concession is a satisfactory one to the Company. I, therefore, propose the following resolution:—"That the directors be authorised and requested to acquire and carry out the concession from the Spanish Government, dated 22nd February, 1879, for connecting Hong Kong with Manila by telegraph, with such modifications, and generally upon such terms as they may think fit, and for this purpose to enter into such contracts, and raise such further capital by the issue of debentures or otherwise, and generally to do such other acts and things as they may deem expedient in this behalf."

The Right Hon. W. N. MASSEY, M.P.: I beg to second that.

The CHAIRMAN: If any gentleman has any remark to make before I put the resolution, I shall be very glad to hear him.

Mr. GRIFFITHS: There is only one remark. The statement you have laid before the meeting is very clear and business like, and I think we are very fortunate in having the opportunity of getting this concession on the terms mentioned. On the other hand, every one who has had any experience knows that the Spanish Government are very bad paymasters [hear, hear]. I have acted on a committee of Spanish bondholders for some years; and time after time the Spanish Government have repudiated their obligations, and obliged us to take very much less than we were entitled to. Unless, therefore, we have some certainty of this £9,600, we may find that this estimated net revenue of £12,000 will be very small [hear, hear].

The CHAIRMAN: I am very glad that you have raised that question, because I think we have gentlemen at this Board who can fully estimate the value of Spanish credit. But we can also estimate the advantage of this cable to the Manila mercantile community. Manila is, perhaps, one of the most prosperous and thriving of the Spanish colonies, and it is the Manila Local Government, and not the Spanish Government, which is to pay the subsidy, and, therefore, we are, comparatively speaking, independent of the Spanish Government; and if they want to play us any trick of that kind we could have the satisfaction of stopping the cable, but I think we need not anticipate anything of that kind from Manila.

A SHAREHOLDER: The explanation of the Chairman alters the case very materially. I quite approve of what the last gentleman said, that it requires our serious attention to see that we do not lay a cable and then get nothing for it.

The CHAIRMAN: I assure you that we have had all that thoroughly before us.

Mr. NEWTON: Does the subsidy continue if the line is not open for traffic?

The CHAIRMAN: It is subject to the usual regulations. People are not likely to pay for what they do not get. We look on it as a perfectly safe contract as arranged by us. Now, those in favour of the motion hold up their hands. To the contrary. Carried unanimously. Now, gentlemen, the next resolution relates to the appointment of an auditor in place of the late Mr. John Ball. I explained to you in my opening remarks about the auditor. It appears that, under the articles of association, we ought, strictly speaking, to have called a special meeting for the appointment of his successor, but you have to-day entirely exonerated us by passing the accounts. We thought it a great pity to trouble you to attend a special meeting so near this meeting; and we thought that what Mr. Ball (a member of the firm of Quilter, Ball, and Co.) did, his firm could do equally well, and we therefore asked Messrs. Quilter, Ball, and Co. to complete the audit to the 30th of June. We now want, if possible, to remove anything like the chance of inconvenience to the shareholders, and also to the directors in the future; and we would suggest that instead of an individual member of Quilter, Ball, and Co's. firm being nominated the auditor, it would, perhaps, give greater confidence if the firm of Quilter, Ball, and Co. should be nominated as auditors of the Company, and they might select their own partner to attend to the duties. But we shall have the responsibility of the firm, and shall not suffer inconvenience if any individual member of it should be out of town, or should die. If the shareholders approve this suggestion I would recommend that a shareholder of the Company—because the appointment of auditors rests ent rely with the shareholders—that he should nominate Messrs. Quilter, Ball, and Co.

Mr. HOBBS: I beg to nominate Messrs. Quilter, Ball, and Co. as auditors of the Company, in the place of the late Mr. John Ball, and that the remuneration shall be the same as previously.

Mr. W. FORD: I beg to second that.

Mr. STOKES: I think we should have a shareholder appointed as auditor. Does Mr. Dever hold shares?

The CHAIRMAN: Mr. Deloitte (his partner) holds shares. But at the very first time I presided at meetings of these telegraph companies I said to the shareholders that I thought it was very desirable that the accounts of the Company should be in the hands of a well-known public accountant. It would be more satisfactory to the shareholders, and would take a very great responsibility from the shoulders of directors. I may mention now that Messrs. Deloitte, Dever, and Co., from that day to this, have had the constant audit of everything that is done at our office—in fact, they are complete masters of our counting-house. But what we propose now is that their business be audited by an independent firm. Mr. Dever remains still.

Mr. NEWTON: I quite agree with Mr. Stokes that we should have an independent audit apart from the audit of public accountants. As to public accountants in the city of London they are not worth that much (snapping his fingers). As an auditor of public accounts I have had the misfortune to have gone through the accounts of a public company that were audited by one of the first firms in the city of London—probably the most respectable and the most ancient, and I say it is impossible to understand them. I therefore think it very desirable that there should be an independent shareholder appointed not connected with any firm of accountants, but that he should hold 100 ordinary shares in the Company, so that the shareholders should know that the accounts are audited by one of their own body. The professional accountant sends a clerk, and the professional man who gets the money comes and inspects the accounts during half a day or for a few hours, and he can know nothing of the work except what he has told him by the clerk. Appoint some one we can look to for the correctness and accuracy of the accounts—a shareholder; but let him hold a certain amount of stock—something like 100 shares. It is only just to us, after the experience of the past four or five years, that we should have an independent investigation apart from the professional firm of accountants, who do the business sometimes in a very perfunctory manner. I see a certain gentleman here. I don't know that he would be would be willing to act, but I should be very glad if he were appointed. Don't let us have two professional firms. We cannot have a better firm than Deloitte, Dever, and Co., and the accounts are well audited by a member of that firm, and Mr. Deloitte holds shares.

The CHAIRMAN: This question is entirely a shareholder's question, and I should be very sorry to do anything more than express an individual

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opinion in the matter. I am not going to force any auditor on you, and I am sure that my colleagues will join me in that; but what we do want if there is any outside man appointed is that he should be competent for that position, a man well known in the City as a man of high reputation and character. I rather doubt whether you will get the man that I should like to see appointed, who would give the time that is necessary to go through all the accounts. There is another reason I would give. Surely a man who makes it his profession, whose business it is day after day to sift and go through accounts, is to be preferred. If he is a shareholder so much the better, and, therefore, I am quite prepared to waive the appointment of a firm; but any individual of that firm, or any other highly respectable firm—a man who is trained to the work, who is a shareholder, must be, from his training, much more suitable for our purpose than a man who has not had that training [hear, hear]. Now, then, Mr. Hobbs has proposed this resolution, and Mr. Ford has seconded it, and those in favour of the resolution please hold up their hands. To the contrary—one dissentient. I would mention, gentlemen, that as you have appointed a firm, I will suggest to the firm that they should nominate one of their partners, and that the partner should be a shareholder in the concern.

Mr. FORD: I venture to think, sir, having a considerable holding in this Company, that it is not necessary.

The CHAIRMAN: Very well.

Mr. FORD: It is not on their holdings, but their experience, position, and integrity that we must rely.

The CHAIRMAN: Quite so. That concludes the business of the meeting.

Mr. STOKES: Colonel Glover was to give us some little account of his visit, and as to when the cable is to be repaired.

The CHAIRMAN: Well, I don't know that Colonel Glover could add anything to what has been said.

Mr. STOKES: When is the cable going to be repaired?

The CHAIRMAN: You may hear of it at any moment.

Mr. GRIFFITHS: Gentlemen, I think every question which has been put has been courteously answered by the Chairman, and, therefore, before we separate we should give our thanks to the chairman and the directors for their conduct of the company's affairs during the half year. I beg to move a vote of thanks to them.

Mr. STOKES: I shall have great pleasure in seconding that. The chairman has given us every explanation that we could desire.

Mr. GRIFFITHS formally put the motion, and it was carried unanimously.

The CHAIRMAN: Gentlemen, your approval is our reward. We are very much obliged to you.

The proceedings then terminated.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).

The fifth ordinary general meeting of the shareholders of this Company was held on Wednesday, October 22, at the City Terminus Hotel, under the presidency of Mr. C. W. Earle.

Mr. C. M. HOOPER, the secretary, read the notice convening the meeting, and the minutes of the last general meeting, which were confirmed, and the report, of which an abstract has appeared in *The Electrician*, was then taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, said that apart from the dissatisfaction they must all feel at meeting the ordinary shareholders without a dividend, he felt particularly a depression in having, half year after half year, to meet them with the same old story of unsuccessful results entirely attributable to the insufficiency of their traffic. The history of the Company was one that went far to disprove the suggestion contained in the old saying of it being a long lane that had no turning. They had travelled that lane for some time, and although they had thought they saw rays of light occasionally coming across their path, it must be admitted that all those bright hopes had gradually faded away, and they could only come to the conclusion that, looked upon as a field for telegraph enterprise on a commercial basis, the West India colonies were unprofitable. It was said that the man who waited long enough always got what he wanted, but, unfortunately, in their case, while they were waiting the cables on which they depended were running through their span of natural existence, and were approaching that decay which must end in the cessation of their operations, and unfortunately during their lifetime they had not been able to put by such reserves as were sufficient to relay or restore them when they ceased to work. With these facts staring them in the face, it was natural to ask, what was their policy? Were they to see their cables gradually dying out before their eyes, and to see the eventual loss—he did not say when it was to occur—of a great part of the capital sunk in the endeavour to connect the West Indian colonies with the rest of the world by telegraph, and were the colonies to be deprived—to lose, in fact, their communication with the home country, which in these days almost every colony of any size or importance thought it necessary to have? The only policy that they had—they had tried everything they knew of—was to continue their importunity with those who were so largely concerned in having a continuance of the system. It might be that, before very long, their arguments with them might receive some very practical support in the cessation of some one of their sections, when it would be for the Company to go to them and say that it was impossible—that they could hardly recommend their shareholders to subscribe more capital for the relaying of a cable which had been found so unsuccessful in earning a sufficient revenue. In pursuance of what he might call their policy of importunity they had addressed themselves to the West India Committee—a body of gentlemen in this City who interested themselves entirely, he believed, with the general affairs of the West Indies. Those gentlemen met them, as they anticipated, with a spirit of enlightenment and courtesy. He thought they saw very readily the state of the Company's circumstances which they laid before them, stating all that they feared and anticipated; and, in fact, they consulted them on the best measures to take to remedy the condition of things from which they were suffering. It was then decided to ask the Secretary of State for the Colonies to receive a deputation of the West India Committee and themselves, and this request was acceded to. Their position and circumstances were laid before the Colonial Secretary, who acknowledged the great interest he felt in the communication with the West Indies being kept up, and the great concern with which he would regard any curtailment of the facilities which at present existed for such communication. At the same time, he pointed out to the deputation that the granting of any assistance to the Company was a matter for the Treasury, and said that he would communicate to them his reply as soon as he could obtain an answer from that department of the Government. It was not for them to express their thanks to the West India Committee for performing what they considered a public duty—he thought that that was a matter for the West Indian colonies; but he was glad to acknowledge publicly the courtesy and the generous support they gave to the Company's concerns. Mr. Chambers, who took part in the deputation, was formerly a director of the Company, and he had ever been ready to give them his advice; and Mr. Bravo, a member of the West India Committee, was also equally ready to give them the benefit of his assistance and advice. Reference was made in the report to the action of the Government of Demerara in stopping the subsidy. They very much regretted that that colony should have taken such a proceeding. They thought it a very bad precedent, and it was unfortunate that they should have thought it necessary or advisable to add to the burdens of a struggling Company like theirs, which had really made no profit out of the enterprise, by curtailing one of the means of their existence. There might be many circumstances justifying the contract being read according to the very strictest interpretation which could be put on it. If the Company were revelling in large profits, or had a large subsidy, or had delayed in their affairs, he thought the Government would have been justified in saying, "Your communication has ceased, and therefore we will not pay the sudsidy;" but, in the case of Demerara, these circumstances had not occurred. It was a subsidy of only £3,000, for which they gave very large services to the colony, and they took every measure they could to repair their cable as quickly as possible. It happened, however, at a very unfortunate time. The Investigator had just been blown to pieces, and there was a little delay in repairing the cable—two months. They had only taken off the amount of the subsidy for the time the cable was interrupted. He was still more surprised at the arguments of the Attorney-General of that colony in advising his Government to take this course. He said that the Company ought always to have a cable ready to put down at the moment a defective piece existed. Well, although they were not bound to do so, they had duplicated their cable all the way between Cuba and Trinidad, but it sometimes happened that both those cables were simultaneously broken. Another argument the Attorney-General rested on was that the cable was originally defective, but the pieces of cable they had recovered from the bottom of the sea, after being down several years, did not show any mechanical defect. Two or three pieces of cable were then shown to the meeting, and in answer to a question the Chairman said it was one of the India Rubber Company's cables. Continuing, he said that of course if a cable lay over the volcanic rocks that occurred in those seas it could not stand, and the causes of their interruptions were much more to be attributed to the character of the locality in which the cable lay than defects in it. There seemed to be a good deal of misapprehension altogether in the colonies which he hoped might be rectified, and he trusted that the West India Committee would exercise some influence in that respect. They seemed to think that it was the inherent, he was going to say, perversity on the part of the Company which was the cause of their cables being interrupted. In all parts of the world, however, cables were broken, but where there was a good revenue and plenty of means, the inconvenience that occurred did not interfere with the traffic. It was only the poverty of the Company that prevented them from doing more than they had done. He had been struck with an article on this very subject in the *Colonist* of Demerara, an article which contained, in the midst of a great deal of common sense and liberality of feeling, some reflections on the Company which were not deserved. The article, he might say, did not entirely approve of the policy of the Government in this matter, but it traced the cause of their unfortunate position and their impecuniosity to their own folly and bad policy, and particularly in the matter of high rates. Now, those rates were fixed originally by the colonies themselves. The rate originally was for twenty words. Soon after the Company was formed, a very great concession was made by the Company to the public of those colonies, for they diminished the minimum of twenty words to ten words, charging only half the rate fixed for twenty words. It was very much less remunerative to carry a ten word message at half the rate hitherto charged for a twenty word message. When the present Board took office the ten-word rate was in force, and they found after working for two or three years with the system in complete order that there was not revenue enough to pay their working expenses, pay the small dividend they did on two or three occasions, and put by sufficient money for the renewal of the cables. They then applied for an increase of the rates, and the higher rates they were allowed to introduce had resulted in an increased revenue of £18.500 a year. If it had not been for that policy of theirs and that increase of rates, they would hardly have been in existence now, for there were many things they would have been perfectly unable to cary out. He thought it a pity, therefore, that people should have such an erroneous idea, and prejudice the minds of their fellow colonists in this manner. He then moved the adoption of the report and accounts, and the payment of the dividends recommended on the First and Second Preference Shares.

Mr. WILLIAM FORD, a director, seconded the motion.

Mr. ROBINSON thought that the Chairman had taken a too gloomy view of affairs. They had suffered by a decrease of revenue as other companies had, and the expenses had increased by £5,182. These exceptional circumstances might not be expected in future half years. As to the stoppage of the subsidy by Demerara, in the case of another company the deduction was only made after the cable had been interrupted for six months—a period which allowed time for the repair of the cable.

The CHAIRMAN remarked that that was generally the case.

Mr. WILLIAM ABBOTT thought that the Chairman had attached too much importance to the article in the paper he had referred to. He thought that the directors should go on and administer the affairs of the Company as they considered best in the interests of the Company. He would like to know, as the report was only to the 30th of June, whether the colony

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of Demerara had really deducted the subsidy. He thought it would be a very awkward time for that colony to be on bad terms with the Company, looking at the very general rise which had taken place in everything the West India islands produced.

After a few remarks from Mr. VEARES,

Mr. HANCOCK urged the directors to look the facts of the case in the face as men of business in the City were accustomed to do. After speaking of the very great difficulties against which the directors had had to contend, and their depressing effect, he said that some strong measures must be taken if the Company was not to collapse. They had only some £20,000 or £30,000 against a capital of a million and a quarter. He regretted that the directors had only a policy of importunity, and thought it very strange that those who had such a vast interest in the maintenance of the Company's system would not consent to some modification of their arrangements with the Company, so as to make them less burdensome. Some new arrangement must be made with the colonies.

Mr. STYLES agreed with the remarks of Mr. Hancock, and thought that the policy of importunity was neither dignified nor profitable.

A SHAREHOLDER asked if the claim as to the Investigator was on a company or an individual.

The CHAIRMAN said partly on a company and partly on an individual.

Mr. FORD, in reply to some of the remarks, said the object with which he addressed the Colonial Secretary was to show him the necessity, in furthering imperial interests, of guaranteeing the Company some assistance. They received at the time what he considered a most hopeful assurance from the Colonial Secretary, whose remarks he read. He then said that he had spoken of the necessity for some assistance being given to them, not for the purpose of swelling their dividends, but in order to maintain their system. The dividends, he trusted, with the careful management which the Company received from its directors, would follow in the future, when they could ensure the permanence of the maintenance of the system. He then referred to the recognition in other quarters of the principle of granting subsidies. As to the increase of their rates, that had saved the Company. On all grounds, imperial, colonial, and journalistic, he saw the necessity for assisting the Company, in order to enable it to continue the useful purpose it had hitherto served.

The CHAIRMAN, in reply to questions, said they had entered into a contract for picking up the Investigator for £14,500, and it was expected that the vessel and its machinery would be picked up for £16,000. They had had no offers from the underwriters with respect to the vessel, and the claim for the amount of the insurance was awaiting settlement at law. They had received information that up to the present Demerara had withheld the subsidy. The motion was then put and carried unanimously, and

On the motion of Mr. ROBINSON, seconded by Mr. BRAVO, a cordial vote of thanks was passed to the chairman and directors.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The following report of the Directors will be submitted to the meeting on Tuesday, October 28:—The directors submit the annexed accounts and balance-sheet for the half year ended 30th June, 1879: The revenue for this period amounted to £75,083 13s. 11d.; the working expenses to £13,452 14s. 4d., leaving a balance of £61,630 19s. 7d. To this is added £23,301 16s. 9d., the undivided profits to 31st December last, making a total of £84,932 16s. 4d. After deducting income tax (£832 11s. 9d.), there remains a balance of £84,100 4s. 7d. A third interim dividend, amounting to £16,250, has been distributed since the last accounts were presented, leaving the sum of £67,850 4s. 7d. for appropriation. The directors now recommend the declaration of a final dividend of 2s. 6d. per share, free of income-tax, making a total dividend of 5 per cent. for the year ending 30th June, 1879, which will absorb £16,250, leaving a balance of £51,600 4s. 7d. Of this amount £50,000 has been placed to the reserve fund, increasing that fund to £227,437 8s., and £1,600 4s. 7d. carried forward. The Company's cables continue in good working order.

In the following table is given a corrected summary of the published monthly traffic returns from the opening of the Company's cables in June, 1874:—

FINANCIAL YEAR ENDED 30TH JUNE.

MONTH.	1875.	1876.	1877.	1878.	1879.
July	£8,243	£10,159	£8,034	£9,329	£10,345*
August	10,012	9,962	9,264	9,513	9,890*
September	8,451	9,478	10,286	9,357	9,204*
October	10,853	10,503	9,812	11,387	11,567*
November	11,120	10,754	11,691	12,233	11,219*
December	11,429	10,186	13,855	12,318	12,525*
January	12,324	12,146	11,587	11,883	12,345*
February	10,008	12,075	11,725	9,676	11,675*
March	12,410	12,654	11,374	14,239	12,997
April	11,723	9,566	11,658	10,367	12,929
May	12,266	11,503	12,378	12,571	12,828
June	9,622	10,052	9,843	11,130	12,130
Total	£128,461	£129,038	£131,507	£134,003	£139,654

* These amounts are the Receipts after adjustment of the accounts with the Western and Brazilian Telegraph Company.

The investments in respect of the reserve fund on the 30th June amounted to £172,120 17s. 3d., consisting of—

£ s. d.		COST. £ s. d.
43,929 15 10	Metropolitan Board of Works 3½ per cent. Stock	45,000 0 0
38,814 1 0	India 4 per cent. Stock	40,000 0 0
15,000 0 0	London and St. Katherine's Docks 4 per cent. Bonds	15,000 0 0
16,000 0 0	Great Eastern Railway 4 per cent. Debenture Stock	16,782 1 0
11,212 0 0	Great Western Railway 4 per cent. Debenture Stock	12,047 8 1
10,000 0 0	Midland Railway 4 per cent. Debenture Stock	10,739 5 0
9,588 0 0	Furness Railway 4 per cent. Debenture Stock	10,000 5 5
8,320 0 0	London and North Western Railway 4 per cent. Perpetual Debenture Stock	8,966 7 3
3,500 0 0	London and South Western Railway 4 per cent. Perpetual Debenture Stock "A"	3,776 5 7
9,695 0 0	Glasgow and South Western Railway 4 per cent. Funded Debt	9,809 4 11
	Total as per balance-sheet	£172,120 17 3

Since the 30th June the directors have made the following further investments on account of the reserve fund, viz.:—

£ s. d.		
9,450 0 0	Metropolitan Railway 4 per cent. Debenture Stock	9,994 19 3
5,000 0 0	Great Eastern Railway 4 per cent. Debenture Stock	5,294 11 3
5,000 0 0	Glasgow and South Western Railway 4 per cent. Funded Debt	5,194 6 3
	Total investments	£192,604 14 0

By Article 76 of the Articles of Association Mr. Frederick Youle and Sir James Anderson will retire by rotation, but being eligible for re-election, they offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES OCT. 22.	BUSINESS DONE WEEK ENDING OCT. 22. Highest.	Lowest.
Anglo-American Ordinary	55½, 6	59⅛	54⅝
Do. "B"	81, 2	84½	80½
Do. "A"	31½, 2	35⅞	29¾
Brazilian	7 1-16, 7 3-16	7 3-16	7
Cuba	8, ½	8¼	8
Do. Ten per Cent. Preference	15, 16	—	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	10½, 11	10⅞	—
Direct United States	10⅝, ⅞	11⅛	10⅝
Eastern	7 15-16, 8 1-16	8⅛	7⅞
Do. Six per Cent. Debenture	103, 106	106¾	103½
Do. Five per Cent. do	103, 105	103¾	103¼
Do. Six per Cent. Preference	12, 12⅛	12¼	12
Eastern Extension	8, 8⅛	8 3-16	8
Do. Six per Cent. Deb.	105, 108	107	106¼
German Union	7¼, 7¾	—	—
Globe Telegraph and Trust	4 15-16, 5 1-16	5 5-16	4⅞
Do. Six per Cent. Preference	11 1-16, 11 3-16	11⅛	11
Great Northern	8½, ¾	8⅝	—
Indo-European	22, 24	22¾	—
Mediterranean Extension	2¾, 3¼	—	—
Do. Eight per Cent. Preference	9¼, 9¾	9¾	—
Reuter's	9, 10	9¾	—
Submarine	225, 230	228	—
West India and Panama	1½, 1¾	1 11-16	1 9-16
Do. Six per Cent. Preference	8, 8¼	8⅛	7¾
Western and Brazilian	3⅜, 3⅝	3¾	3⅜
West. Union Seven per Ct. 1st Mt.	123, 128	123	—
Do. Six per Cent. Sterling	105, 107	106⅛	104⅛

TRAFFIC RECEIPTS FOR SEPTEMBER, 1879.

COMPANIES.	Sept. 1879.	Sept. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,463	537	—
Direct Spanish Telegraph Company	1,121	1,048	73	—
Direct United States Telegraph Company	21,080 estd.	—	—	—
Eastern Telegraph Company	39,369	38,169	1,200	—
Eastern Extension Telegraph Company	26,980	22,151	4,829	—
Great Northern Telegraph Company	18,775	—	—	—
Submarine Telegraph Company	11,911	9,661	2,250	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	1,200	—	—	—

REFLECTORS FOR EVERY DESCRIPTION OF ELECTRIC LIGHT.—Chappuis' Patents. 69, Fleet-street.—[ADVT.]

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NOTES.

THE GUILDS INSTITUTE LECTURES AT COWPER-STREET.—Professor W. E. Ayrton informs us that his inaugural lecture on Saturday, Nov. 1, will be supplemented by a large number of illustrative experiments.

NICKEL PLATING.—The Société Française Anonyme de Nickel are showing an assortment of articles at the exhibition now being held at the Palais de l'Industrie, Paris. The articles in question are described as a sort of white nickel bronze, which is said to be harder than copper and inoxidisable.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Board have resolved upon the payment of an interim dividend of 5s. per share, being at the rate of five per cent. per annum for the quarter ending 30th September, 1879, such dividend to be payable on and after the 15th November, 1879.

THE PULLMAN DINING CAR.—To-day the Great Northern Railway commence running with the Leeds express a Pullman car fitted up as a dining room. Dinners, similar to those obtained in an ordinary restaurant, can be obtained in this carriage any time during the journey. We noticed during the recent trial trip to Peterborough that the car was fitted with electric bell apparatus.

NEW USE FOR IRON RAILS.—The engineer of the San Paulo Railway in Brazil has hit upon a novel way of utilising the old iron rails which have been superseded by steel, by making them into telegraph posts, and thus overcoming the trouble and annoyance occasioned in all tropical countries through the destruction of the wooden posts by ants. These rails, when originally laid down, cost £11 per ton, and the steel rails which have displaced them have cost only £4 10s.

OPTICAL TELEGRAPHY.—The French Minister of War has published a regulation for organising optical telegraphy in time of peace. The several places on the French frontier are to be connected by posts; apparatus are to be manœuvred by persons trained and keeping records of communications sent or received. This new service is to be placed under the supervision of the Director of Aërial Communicaions, who already has command of the balloonists and the colombophiles for carrier-pigeons.

OBITUARY.—Mr. C. P. Edison, the nephew of Mr. T. A. Edison, died a few days ago in Paris at the early age of 24. Mr. Edison came over from America last year, bringing with him the laboratory telephone receivers which have been so often mentioned in our columns. He had recently been engaged in applying a system of quadruplex working between Paris and Brussels. It is singular that Mr. Adams, who acted on this side of the Atlantic for Mr. Edison prior to his nephew, also died at Paris.

A NEW COMPANY.—THE SHIPS' ELECTRIC TELEGRAPHY COMPANY, LIMITED.—Capital £10,000, in shares of £5. To carry on the manufacture and sale of electric, pneumatic, mechanical, and other machinery, whether for the purpose of telegraphy or for any other. The subscribers (who take one share each) are—W. J. Oliver, 3, Bloomfield-terrace; C. Winch, 4, Lancaster-place; John S. Gisborne, 11, London-street; J. B. Wescott, Hackney; H. E. Crozier, Kingston-on-Thames; W. T. Jennings, Brixton; C. J. Minney, 29, Brompton-crescent; L. Swift, 11, Lawrence Pountney-lane, E.C.

BULGARIA.—The Bulgarian Telegraph Bureau, says *The Times* correspondent, has prohibited internal telegrams in the English and Italian languages, French, Russian, and German telegrams being, however, permitted. It is high time that England took some official action in regard to the telegraphic use of the vernacular in the east of Europe. In Roumania, English telegrams are refused unless accompanied by a translation, while all other European languages are accepted at the Roumanian telegraph offices without translation. The European Telegraphic Convention scarcely contemplated such a situation of affairs with regard to the telegraphic use of the English language, in time of peace especially.

TELEGRAPH AGENCY IN ITALY.—"Reuter" is almost a household word in England, and it seems that similar agencies are to be found elsewhere. In Italy, however, there seems to be some doubt as to the future general usefulness of the agency. The *Globe* in its Notes on Rome says:—"The contract for the telegraphic agency is on the point of expiring, and Signor Obleight, a banker, newsagent, and journalist, is likely to succeed Stefani in the agency for telegraphs. He is part owner of the *Libertà* and *Fanfulla*. Most of the other journals are alarmed at the prospect of the agency falling into the hands of a gentleman who will have the power of reserving the most important items of news for his own newspaper."

TELEGRAPHING WITHOUT WIRES.—Our American contemporary the *Journal of the Telegraph*, states that Prof. Loomis continues his experiments in the mountains of West Virginia, to demonstrate the theory that at certain elevations there is a natural electric current, by taking advantage of which telegraphic signals may be sent without the use of wires. It is said that he has telegraphed a distance of eleven miles by means of kites flown with copper wires. When the kites reached the same altitude, or got into the same current, communication by means of an instrument similar to that of Morse was easy, but ceased as soon as one of the kites was lowered. He has built towers on two hills about twenty miles apart, and from the tops of them has run up steel rods into the region of the electric current.

ELECTRIC TOYS IN A POWDER MILL.—"At the recent Brentford Petty Sessions two youths named John Brown and Henry Dewey were summoned by their employers, Messrs. Curtis and Harvey, powder manufacturers, Hounslow, for infringing a bye-law of the works by having electric toys in their possession while engaged in the mill. Mr. T. Woodbridge, for the prosecution, said the explosives in question ignited on coming in contact with water, and were, therefore, especially dangerous at the works, because the platform on which the defendants worked was kept continually wet. The youths were liable to a fine of 40s. each, but Messrs. Curtis

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and Harvey did not wish the Bench to impose the full penalty. They felt compelled to prosecute in a case of this kind. It was even against the rules for the workmen to have pockets in the clothing they wore at the mills. The magistrates fined defendants 20s. each."

CYPRUS.—Extract of letter from correspondent, dated Lanarca, 15th Oct. 1879:—"Cyprus is essentially an agricultural island, but owing to the cruel dealings of tax gatherers and usurers the poor farmers have been all but ruined, and only a very small portion of the cultivable land is now under cultivation. There are two things necessary to alter this state of affairs. 1st. The assurance that the island will not again be handed over to the ruinous rule of the Turk. This is necessary to inspire the people with confidence. 2nd. The formation of an agricultural bank to enable the farmers to free themselves from the usurers, and extend their operations. I hear such a bank will shortly be formed. This is very encouraging. You will have seen by *The Times* Famagusta telegram of the 13th that Admiral Hornby's fleet had safely entered and anchored in Famagusta Harbour, having plenty of room to spare. This will effectually set at rest the sneers of many with regard to this harbour. The winter promises to be a good one, heavy showers having already fallen everywhere in the island."

KING THEEBAU AND THE ELECTRIC LIGHT.—It is rather hard upon the King of Burmah, having purchased electric light apparatus, to find the Anglo-Indian authorities throwing obstacles in his path to scientific study. According to a *Daily News* correspondent at Rangoon "His Majesty got the apparatus for the Jablochkoff light down from Calcutta the other day. Part of this, of course, was the cable to be attached to the engine. It entered somebody's head that the same cable which was connected with the candles might be used to let off torpedoes—a notion which took so strong a hold of the Custom House people that they have refused to pass it, and it consequently remains locked up here. Considering that hundreds of thousands of caps and large quantities of guns and ammunition have passed up to Mandalay lately, and no one has been able to stop them, it seems almost spiteful to deprive Theebau of the means of lighting up his palace, especially as it is not pretended that he has any torpedoes capable of being fired by any means other than sticking them on the top of a fire." Persons entrusted with a little authority are absurdly fond of showing it and bringing contempt upon England.

COMPLETION OF THE SUBMARINE TELEGRAPH FROM DURBAN (NATAL) TO ZANZIBAR.—We have received copies of the following messages from the Eastern Telegraph Company:—"Cape Town, Oct. 15 (Sir Bartle Frere to John Pender, M.P.): We congratulate you heartily on completion of cable to Zanzibar. English and Indian news of 3rd received today." Following from Pietermaritzburg:—"The Proprietors of the *Times of Natal* beg to return best thanks to the Chairman of the Eastern Telegraph Company for his courtesy in forwarding the telegram received this day, and send hearty congratulations on completion of the line to Zanzibar. The Colonists have learned with pleasure of the kind remarks of General Wood and Colonel Buller." The portion of the South African telegraph cables, of which the successful laying is announced, is about 2,000 miles in length, with stations at Durban, the southern terminus of the system, Delagoa Bay, Mozambique, and Zanzibar. Between Cape Town and Durban messages are transmitted over the Government land lines. The distance between Zanzibar and Aden, where the new system will join that of the Eastern Telegraph Company, is about 1,800 miles, and as the ships, with the requisite cables on board, are now on their way to Aden, the line is expected to be at work throughout early in December. The cables have been manufactured and laid by the Telegraph Construction and Maintenance Company, for account of the Eastern and South African Telegraph Company, of which Mr. John Pender is Chairman.

THE ELECTRIC LIGHT.—A contemporary quotes the following extract, taken from the *Mechanics' Magazine*, and suggests that a similar paragraph may be read 30 years hence because this was written some 30 years ago. Surely the electric light is not in the same position now as it was in Staite's time, and every improvement brings us nearer the time when its services will be acknowledged and utilised, when its economy will be equal to that of any competitor, and its sanitary properties conduce to render it *the* artificial light beside which none other can be compared. The following was published in the *Family Herald* February 2, 1850:—"The public," says the Editor of the *Mechanics' Magazine*, "have experienced so many disappointments respecting this light, it has been so often represented as attended with 'perfect success,' without that perfect success ever leading to its practical adoption anywhere, that people have fairly enough begun to regard with exceeding incredulity any announcement respecting it. We do not hesitate, nevertheless, to present our readers with an account of one exhibition more, which has been communicated to us by a correspondent on whose judgment and impartiality we place great reliance; for it does appear from it that all the difficulties of the case have at length been really surmounted, and an actual electric lamp produced, which gives a steady, enduring, and most brilliant light, without any perceptible flickering or intermission. On Monday last there was an exhibition at Crosby Hall of Mr. Staite's electric light, which demonstrated more decisively than has ever yet been done the capability of its application to domestic and public illuminating purposes. Mr. Staite made use of a regulating magnet on the plan fully described in the *Mechanics' Magazine*, Vol. L., p. 48, and most admirably did it perform its functions. In addition to the advantage of being self-acting, this apparatus is so sensitive of the slightest variation in the electric current, and so instantaneous in its controlling action, that no unsteadiness of light is perceptible. Mr. Staite also exhibited a small iridium lamp, in which the illuminating medium was composed, as the name indicates, of iridium, and which appeared to be particularly applicable to domestic and other purposes, where a very powerful light is not required, but one that will last long without attention, and be of little cost. Another lamp, in which carbon points were employed for producing the light, was subsequently exhibited, and certainly for steadiness and brilliancy it surpassed every other known artificial light—so powerful, indeed, that the eye could not look upon it without being painfully fatigued. To counteract this to some extent, it was enclosed in an enamel glass globe of about twenty-four inches diameter, which appeared as an enormous globe of pure and brilliant white light. There can be little doubt that ere long we shall see gas and oil lighting, with all their attendant evils of blacks, heat, &c., replaced, at least in all large public buildings and thoroughfares, by the electric light."

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CANTOR LECTURES.*

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece, Electrician to the General Post Office.

Lecture II.

(Delivered Monday, April 28th, 1879.)

You heard, last meeting, what my notions were of the nature and character of electricity, and how it is produced; and you were shown the various forms of batteries that are used in this country in conveying intelligence from place to place. It was quite impossible, in the time allotted to me for these lectures, to go generally into the question of batteries, or to attempt to describe more than those that are really in use in this country.

To-night we shall take the next branch of the subject—that is, I propose to endeavour to show you how we transfer this electricity from place to place.

Now, the operation can familiarly and popularly be said to be almost identical with that which conveys water or gas from one place to another. For instance, in this room we have a very pretty sunlight burner, through which the gas has been passed to be consumed and to give light. The gas is generated miles away (I do not know where, because I do not know what company supplies it), and has been transferred from the gas works, by pressure, through pipes that convey it to this room, and all that we have to do to obtain the necessary light is to ignite the gas, and regulate its passage through the burner by simply turning a cock. So with electricity. We produce electricity in batteries, such as you saw the other night, and we have to supply, not the pipes, but something very much akin to them, to convey it from where it is generated to the place where it is used. The amount of current that is required to operate a given instrument can be regulated with the same exactitude and nicety that we can regulate the quantity of gas consumed, and, in carrying out this, we make use of the two simple functions of the current to which reference was made last time, and that is the electromotive force, or the energy producing the current, and the resistance opposed to its progress. We have, therefore, first of all, to find something that shall be to electricity what air is to light; what pipes are to gas; we want something that shall be transparent to electricity, and we are led to conceive two properties of matter; the one called conduction and the other insulation. Conduction is the term applied (the reverse of resistance) to that property of bodies which enables them to convey electricity, and insulation is that property of bodies which resists or prevents the passage of electricity.

Now, metals, in all periods of electrical history (which is a very short one), have shown themselves to be the materials to be used for the conduction of electricity, and substances, such as gutta percha, india rubber, glass, porcelain, &c., those best adapted for insulation.

The very first telegraph that was ever practically laid down—not the first that was experimentally used—was that which was put down by Cooke and Wheatstone along the Camden incline, in the year 1837. Three or four years ago, in digging up this incline for some purpose or other, pieces of this old original telegraph were brought to light. We call this the "fossil" telegraph, though its age is only a little more than forty years. I have a piece of it here. It consists of a piece of wood, of a pyramidal section, with five grooves in it. In these grooves were placed copper wires, each wire being surrounded by cotton steeped in pitch. A tongue of wood was placed over the wires, they were then placed in the ground, and formed the first telegraph.

In 1840 a line was laid down from Paddington to Slough. That line consisted of copper wires drawn through pitch and other compounds, and surrounded by a lead pipe. But it was soon found that the wires so encased in lead and buried became useless. They were taken out of the ground, and were suspended on posts. Here the first insulator used, viz., a goose quill, was brought into requisition. Posts were arranged every thirty or forty yards, and the copper wire was placed inside the goose quill, the latter article, in those days, being thought sufficient to insulate an electric current. Curiously enough, the experience of the Americans, which commenced in 1844, also began with the use of copper wire, but they used cloth steeped in gum lac as an insulator. Their experience, however, was exactly similar to ours, and was equally valuable, in very soon leading them not only to abandon the use of such primitive insulators, but also to abandon the use of copper wire. Copper expands under the influence of heat. When it expands about 1 per cent., it loses its elasticity, and does not recover itself; takes awkward sags, knuckles into curious forms, and becomes, after a short time, practically useless. It was in those days that we were speedily led to the use of iron wire, and, for overhead telegraphs, iron wire, from that day to this, has practically remained the material used for the conveyance of electricity. The first iron wire used was of the very best kind that could be obtained, known as the best charcoal wire. It was chosen principally for its strength, and for all purposes was quite strong enough, quite good enough, and gave full satisfaction. But after a time notions of economy came in. Charcoal wire was found to be a little too expensive, and another kind, known as "B B" (best-best) wire, was introduced, and for a great many years economy reigned supreme, and this ordinary B B wire continued in use. Other notions latterly came into play. It has been found that the resistance of iron wire to the passage of currents varies very considerably. Different qualities of wire of the same dimensions will allow different quantities of electricity to pass through, and, therefore, the telegraph engineer applied his mind and knowledge of the laws of electricity to the examination of the texture of the material used; and by the application of his knowledge of the laws, and by the introduction of electrical tests, the quality of the iron wire for telegraphic purposes has been improved at least 50 per cent. The wire used at the present day is at least 50 per cent. better than that which was used twenty years ago. I cannot give figures showing the progress in this direction, as exact measurements did not commence until 1869 or 1870; but, from a careful examination of the wires that exist now with wires erected in 1844 and 1850, and allowing for the deterioration due to age, the result shows that our present wire is, as I say, 50 per cent. better. The way in which this quality is proved is simply by measuring the resistance of the wire. If you want to measure the length of anything, you measure it in feet or inches. If you want to measure the quantity of liquid to be used for any purpose you have your gallon, quart, and pint, and in every kind of measurement we have some unit or some standard to refer to. Now, in measuring the resistance of wires to the conveyance of electricity we use a unit—a standard to refer to—and this unit is called an *ohm*. It is a very difficult thing to give you an idea what an ohm is. It really is almost an arbitrary resistance, one that, after a careful and exact examination, has proved to form a connection between electricity, heat, mechanical motion, and all the physical agencies. This peculiar quantity, that is called an ohm, is represented by a yard of platinum wire of given dimensions; it is very nearly represented by a column of mercury one mètre long and one square millimètre sectionally high. But it is really a fixed arbitrary standard, to which all our measurements are compared, and it is as difficult to explain as it would be for me to explain to you what an inch or a foot is. Nobody can tell what a foot or a mile is—they are arbitrary standards fixed for measurement. So with reference to this arbitrarily-fixed standard of resistance that is called an ohm, although, perhaps, it is scarcely fair to call it arbitrary, because it is really a scientific unit based upon our knowledge of the units of time, space, and length. Well, the early wire to which I refer gave a resistance of 20 ohms per mile. The wire which was used in the year 1870, when exact measurements commenced, gave a resistance of 15 ohms per mile. The wire that is now used gives a resistance of under 11 ohms per mile, so you see how our knowledge of the laws of electricity has tended to improve upon the quality of the wire for conducting purposes. Then, again, a wire requires to have a certain tensile strength, and this is maintained at a certain fixed point where we know it to be perfectly safe. The principal point in which we are interested is its durability. When iron is exposed to the air, the moisture contained in the air combines with the iron and forms rust; the rust scales off, leaving fresh surfaces exposed to the moisture, which again is brought into contact with it, and the rusting process goes on, and would result in the wire being rusted through in a very short time. To prevent this rusting, a process, curiously enough called galvanising (although it has nothing whatever to do with Galvini or electricity), has been introduced. The wire is cleaned by acid, is drawn through a bath of molten zinc, and becomes coated with a thin layer of zinc. Zinc has this property, that, when it is once covered with moisture, an oxide of zinc forms which is insoluble, and it remains adhering to the wire, and acts as a perfect protection; and in the clear country (in such country as our South Western Railway passes through, where wires erected in 1844 are as perfect now as when first put up), wires so coated will last for an indefinitely long period. But when we come in the neighbourhood of towns, where smoke and sulphurous acid gases of different kinds exist, there these sulphurous acid gases combine with the oxide of zinc, and form a sulphate of zinc which is soluble, and gradually disappears, and leaves the wire exposed to the rusting process just described. The result is, that in

* From the *Journal of the Society of Arts* for October, 1879.

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many places wires will not last more than three years, and in such places new processes have been adapted for protecting the wires. I have here various samples of the character of wires that are used. They vary in gauge according to the distance they have to travel. Where we have very long circuits, as between London and Glasgow, we require wires of small resistance, which enables Glasgow practically to be brought much nearer to London, and in such cases we use wire which is called, in the Birmingham wire gauge, No. 4.

The Birmingham wire gauge is a meaningless thing in itself, but, somehow or other, it has got into the language of wires, and telegraphists can only speak of wire by its number—No. 4, No. 8, or whatever it may be, although it practically means very little; it would be much better if we could introduce the diameter, and speak of wire by its size in thousandths of an inch, or something like that, and that we are striving to do.

Here is a specimen of "No. 4" wire. It has a diameter of $\frac{240}{1000}$ths of an inch, and wire of this kind is used for very long circuits. The next size smaller, No. 8, is $\frac{170}{1000}$ths of an inch in diameter, and is used for distances of about 200 miles, such as from London to Liverpool. For shorter distances, a still smaller sized wire, No. 11, is used. It is about $\frac{120}{1000}$ths of an inch in diameter. These are really the three sizes of wire now in general use. There is a "strand" wire that is used for crossing over houses, and also a small-sized wire, No. 16, which is used for binding and making joints in No. 8 and No. 11 wires.

The following Table gives the standard particulars of these various gauges :—

TABLE OF GALVANISED IRON WIRES USED FOR OPEN-AIR TELEGRAPHIC PURPOSES.

Nominal Size B.W.G.	Diameter.			Weight per Mile.			Minimum Breaking Weight for Standard Diameter.	Minimum Number of Twists in Six Inches.	Maximum Resistance per Mile of the Standard Weight at 60° Fahrenheit.	Constant, being Standard Weight × Resistance.	Weight of Each Bundle.		Minimum Weight of each Piece or Coil of Wire.
	Required Standard.	Minimum.	Maximum.	Required Standard.	Minimum.	Maximum.					Minimum.	Maximum.	
	Inches.	Inches.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.		Ohms.		Lbs.	Lbs.	Lbs.
4	·242	·237	·247	800	767	833	2,150	14	6	4,800	90	120	90
6	·209	·204	·214	600	571	629	1,600	16	8	4,800	90	120	90
8	·171	·166	·176	400	377	424	1,075	20	12	4,800	90	120	90
11	·121	·118	·125	200	190	213	540	27	24	4,800	80	112	40
								In 3 inches.					
16	·066	·063	·069	60	55	65	—	20	80	4,800	28	112	5

NOTE.—In the case of wire not equalling the minimum breaking weight for standard diameter, as shown in the Table, the allowance named below will be conceded in consideration of the number of twists being above the minimum.

For No. 4 Wire—for each additional twist 40 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 2,000 lbs. be accepted.

For No. 6 Wire—for each additional twist 30 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 1,500 lbs. be accepted.

For No. 8 Wire—for each additional twist 20 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 1,020 lbs. be accepted.

For No. 11 Wire—for each additional twist 10 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 500 lbs. be accepted.

In places where smoke abounds, and where decay is rampant, we endeavour to protect the galvanised wires by coating them, sometimes with hemp and tar, and sometimes with tape served with a preservative compound of some kind or other. The South Western Railway was one of the first places where this preserving process was used. The wire erected on that railway was coated with hemp that was well tarred, but it proved an insufficient protection. The hemp rotted; and those of you who are in the habit of travelling along this railway will be familiar with the festoons of this stuff hanging from the wires, which has a very disagreeable appearance. I was asked, only last week, by a friend of mine, "What that fungus upon the wires was?" An improvement upon this process was that introduced by Messrs. Brooks, who serve the wire with a covering of prepared tape. Samples of wire so prepared are now before you. But a process was introduced in America which really was very promising, and that was one by which the wire itself was protected with copper. A core of steel wire was taken, which was surrounded by a layer of copper, the whole being tinned together; and it was hoped that, by this process, the wire would become protected from the deleterious gases of the atmosphere. But it was unfortunate that the metals used were of varying expanding properties, and the result of the combination was that, after a little time, the copper covering cracked, moisture got inside, and attacked the inner metal, and very soon the whole arrangement was given up as unsatisfactory. Four hundred miles of wire prepared in this manner were sent to China, and although it was never put up, but remained in store, when it was overhauled it was found to be quite unfit for the purpose intended. We put some up in South Wales, and it only lasted three years, and a very little experience very soon condemned the whole arrangement.

But another and more promising process has been introduced, also in America, by Messrs. Wallace Brothers, of Ansonia, Conn. In this process, a core of steel wire is taken and passed through a bath of sulphate of copper, which is under the operation of a very powerful current of electricity, and the result is, that the copper contained in the solution becomes deposited in a thick layer on the wire, and is homogeneously fixed around it, so that there is no joint to burst, or any crack to be made by expansion. This process is really very promising, and is now under actual trial. The great advantage of such a wire is that, while it gives us the advantage in point of resistance of No. 4, it is as light as No. 11, and as strong as No. 8. For long distances, such as carrying a wire 3,000 miles over the centre of Africa, such a wire would be invaluable; but we have not yet had sufficient experience of it to say that it has acquired a thoroughly practical form.

The accidents to which telegraph wires are subject are sometimes very curious. Of course there are many accidents to which all wires are liable—accidents along road and railway—but our great enemies are birds. In some parts of the country birds alight upon the wires in great flocks, and they all, by some curious instinct, fly off together, and set the wires vibrating, causing them to come into contact. This is especially the case at that time of the year when the migrating birds congregate prior to leaving our shores; and in the southern parts of England, in the Isle of Wight and neighbourhood, we are especially troubled by contacts put on by birds. I have had a case of a wire being absolutely broken by a goose flying against it. You would scarcely conceive it possible that a goose could have sufficient strength of wing to break a wire; but on the South Western line there was a case where a No. 8 wire was broken by a goose flying against it. Of course, I need not say that the animal itself suffered considerably, as well as the wire. In India, the vultures have a curious habit of dropping the entrails of animals they devour upon the wires, and this is one great cause of interference to the working of the wires in that country. In England, on the Midland Railway, I have known of a snake being dropped on the wires, causing a fault which we call contact, and so disturbing our working.

You will observe that the advance that has been made in the wire has been principally in its electrical conducting qualities. Its strength remains the same; its size remains the same; it has become cheaper that it used to be, from the greater demand and less cost of production; but the care and thought that have been applied to the substance of the wire have been the means of improving its electrical capacity in the proportion I have mentioned, viz., nearly 50 per cent.

Now, as to that which supports the wire. Wires are suspended

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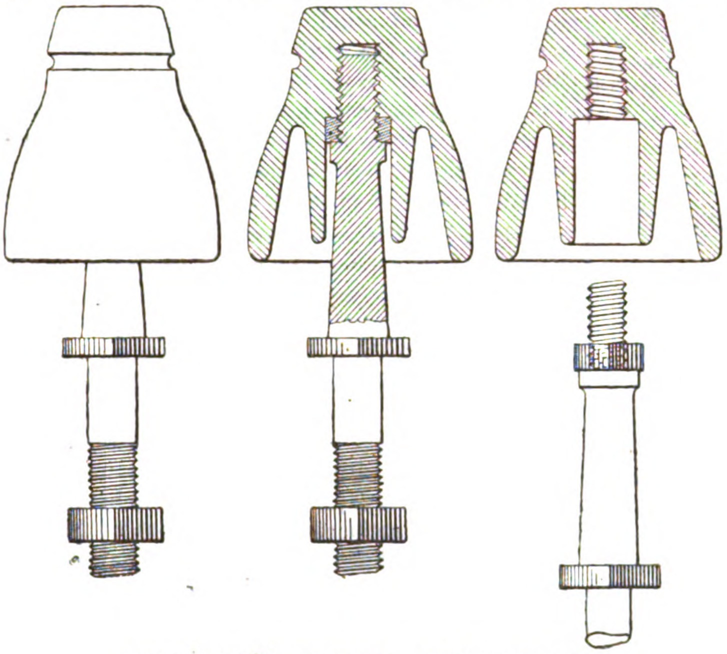
along the line from pole to pole, at distances of about 80 yards; and at every point where the wire rests against the pole (the pole itself being a conductor), if it were not protected in some way, the electricity passing through the wire would fly to the earth and disappear. I told you that on the first line the insulator that was used was a goose quill. This was speedily replaced by an ordinary earthenware ring, and from that day to this changes have been going on—from rings to cups of all kinds and forms, made of either earthenware, glass, white porcelain, black ebonite, or any other material that the genius of the inventor or manufacturer could bring forward. In this field we have been taught what to use solely by experience. From 1840 to the present day everybody who has had anything to do with telegraphy has been devising some dodge by which the power of our insulators can be improved; and the concentration of experience of telegraph engineers all over the world has been to show that the best material is white porcelain. On the pole before you we have samples of the different kinds of insulators that are in use. The white porcelain one is used to a very large extent in this country. The two brown earthenware ones on the lower arm are also extensively used here. They were, I think, introduced by Mr. Varley about 1860.

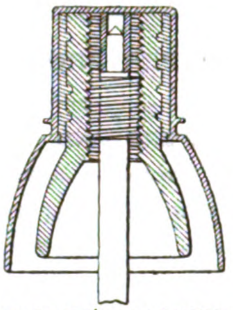
Here is an iron-capped white porcelain insulator which has been recently introduced by Messrs. Johnson and Phillips. It is peculiar in this way, that between the wire and the bolt the current would have to pass through a cup which is full of oil. Oil is a capital insulator—one of the very best insulators that we have. A current, in escaping, would have to pass through the oil, which offers something almost irresistible to its passage, and thus the insulator is an almost perfect one. But at the present moment the practical experience of its mechanical properties is not very satisfactory. It is still undergoing a trial, and cannot, therefore, be said yet to have been adopted. The use of insulators is a very important matter with us in the Post Office. For instance, from the figures of the past three years the average annual number of insulators used by us has been 86,000. The kind that we are now adopting is the one you now see, Cordeaux's Screw Insulator (Fig. 5). Its principal merit is the considerable length of surface that a current of electricity has to flow over before it can escape through the bolt and pole to earth. There is the outside cup and another cup inside, inasmuch as it has been found by experience that, to maintain the insulation of a line perfect, you must keep your supports clean. Any of you who are in the habit of making electrical experiments must know how essential it is to wipe your supports, and keep your insulating points perfectly clean. And when you erect a line, as between London and Liverpool, and imagine that your insulators are going to keep clean for 100 miles or more, and always to remain the same, you make a very great mistake. The chief merit of this insulator is that it has the means of being readily removed. It unscrews, can be cleaned, and then simply screwed on to the bolt back again, and is as good as ever. So that, while the outer cup, from its large surface, has the power of insulating very fairly, the insulator also has the great advantage of being readily cleaned.



CORDEAUX'S SCREW INSULATOR

Fig. 5.

The telegraph lines of the Post Office suffer tremendously from the breakage of insulators, caused by stone-throwing, and a large portion of the 86,000 I have just mentioned is absorbed in replacing damage in this respect. Insulators make the best cockshies in the world, and I do not know of anything more tempting to a fellow walking along a road full of stones than to take up one, and have a shy at one of these white insulators. The result is that many insulators are broken from stone-throwing. Lightning, again, undoubtedly breaks a great many insulators; perhaps not so many in England as in other countries, but, nevertheless, we do suffer to a certain extent. Here (Fig. 6) is an iron-covered insulator that has been recently introduced, which also is a lightning protector. It is protected with an iron cap, and the bolt screws in, so that it brings, opposite this iron cap, a point of the bolt that supports it. This bolt is prevented from touching the iron hood by an ebonite washer; when it is screwed into its place, a little cement is put in to make it absolutely tight, and there you have an insulator and lightning protector. It is one of the most recent inventions in this direction, and is the invention of Mr. Oppenheimer, of Manchester. This form of insulator has been sent out in large quantities to Australia, where they suffer very much from lightning, and I think it is very likely that it will be sent out to other countries where similar experience is felt.



OPPENHEIMER'S LIGHTNING GUARD INSULATOR.

Fig. 6.

To give you an idea how essential it is to protect lines with insulators from the escape of the current, I may mention this, that one of the severest tests that we have in this country to the efficient working of our lines is due to those storms that come up in the winter from the south-west.

We unfortunately live in a country which is said to have a climate, and a villainous climate it is. This curious country of ours is washed by the warm Gulf Stream. The warm Gulf Stream generates clouds of aqueous vapour. This aqueous vapour, when it comes in contact with the colder ground of our little island, is thrown down in the form of rain. But there are periods when immense clouds of this aqueous vapour pass over our island that do not produce rain, but they produce upon our insulators a thick coating of moisture, and there are one or two days in nearly every year when the air becomes, as it were, supersaturated with moisture, which, when it comes in contact with any substance (such as our wires) a little colder in temperature, deposits this moisture upon it in the form of water, that acts as a conductor and impedes working.

We try to get our insulators to offer a resistance to the passage of the current equivalent to 100,000 megohms each, and one megohm (or one million ohms) per mile is the standard to which we try to work. In very wet weather it frequently comes down as low as 300,000m. per mile, but on the 22nd and 23rd of November, 1877, many of our lines skirting the sea coast fell down as low as 20,000m. per mile. The result was that there was a practical breakdown throughout the whole country. The same thing took place on the 20th November last, between five and six o'clock in the evening.

(TO BE CONTINUED.

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ELECTRO-DEPOSITION UPON IRON AND STEEL.

Writing in 1875, Mr. Sprague, in his useful work entitled "Electricity; its Theory, Sources, and Applications," observes in respect to nickel plating, that "this process has come into much use in the last few years, and, unless arrested by the great advance in the price of nickel which it has caused, it bids fair to be very largely employed for many articles in common use.". Since that period, there has certainly been some extension of the very useful process of protecting articles of iron and steel from corrosion by means of a coating of nickel; but we think that the extension is as yet by no means commensurate with the practical convenience and general importance of employing such a protection. Either the British public, never very quick in adopting innovations, is even abnormally slow in recognising the advantages in this direction, or manufacturers have insufficiently stimulated demand by a varied and well-advertised supply. In regard to nickel itself, we believe that this metal may now be obtained, in almost unlimited quantity, at a lower price than has yet prevailed. In this instance an increased demand has vastly stimulated the supply. In America, the adoption of the nickel coating, for the protection from rust of small articles manufactured of iron or steel is, we are told, rapidly becoming universal; and, with their wonted enterprise, our transatlantic cousins are exporting to this country nickel-plated tools which are selling at about the same, or even at a lower price than tools of English manufacture, of the same quality but without the nickel coating. In London, we observe that one or two manufacturers and sellers of novel and tasteful utilities have shown a praiseworthy alacrity in placing before the public various articles of steel, protected and improved in appearance by a coating of nickel. We fear, however, that this limited amount of enterprise has received but scanty encouragement. The truth is, we think, that the English public requires to be educated on the subject of the advantages to be obtained by the electro-deposition of metals other than gold and silver. Nor, indeed, should we make an exception of the latter metal, since it has hitherto been very insufficiently utilised in some directions, as, for instance, for table cutlery, to avoid the labour and wear consequent upon the usual modes of cleaning such articles.

Looking into the well-stocked shops of our London cutlers, how seldom do we see any goods protected by a coating of nickel or silver—to say nothing of antimony, bismuth, bronze or platinum deposits, or coatings of certain oxides and sulphides, all of which are in various cases susceptible of being utilised, and will doubtless at some period come into extended use. Yet is there no class of goods requiring protection more than those which are there exhibited. That this is the case is sufficiently evidenced by the number of articles which, even whilst exposed for sale, have become more or less spotted and discoloured with rust, and thus not merely spoiled in appearance but deteriorated in character. For it should be borne in mind that, whereas articles of polished steel, whilst free from any spot of rust, will ordinarily—even in presence of moisture, if ammonia and acid vapours be absent—resist oxidation to an extent that is somewhat surprising, when we consider the position of the metal in the electro-chemical scale, one such spot of oxide causes a rapid spread of oxidation, due to the fact that it constitutes, with the liberated carbon underlying it, a very efficient negative element, in a couple of which the unattacked steel is the positive, and any deposit of moisture the electrolyte. No doubt, a polished steel surface is, in its way, beautiful, and consequently attractive; but the beauty is ordinarily of the most transient character, and the attractiveness is therefore delusive. The equally polished yellowish-white coating of nickel, or the more brilliant covering of silver, are also beautiful, and their attractiveness is permanent so long as the deposit remains unbroken and entire. And, since these surfaces do not require to be cleaned by a process of wear and abrasion, the coating, when properly deposited and of sufficient thickness, will last for many years—the article retaining its original appearance, and an economy of labour and material being effected. When at length it begins to show signs of wear, the coating can, by a process recently devised, be repaired at those points where the wear is greatest; or, with our present appliances, the article can be "stripped" and re-coated at a cost which,

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everything considered, leaves the advantage of economy considerably on the side of the electro-deposition process.

By purchasing at the cutlers, in duplicate, some small articles—let us say a pocket knife, a pair of scissors, and a table knife, the questions involved in the above considerations may be very instructively tested by experiment. Let the primal brilliancy of the articles be duly noted and appreciated before the affinities which result in oxidation have had time or opportunity to act. Then place one of the pocket knives in its proper receptacle, and one of the scissors on the office table or dressing table, and hand over the table knife to the housemaid. In regard to the remaining set of articles, the pocket knife may, without injury to its handle, be immersed in any of the ordinary nickel baths, and plated with that metal; after which the sharpness of the blades may be restored by passing their edges over a hone or emery knife-sharpener. Or, still without any injury to the handle—such as might result from the use of a strongly alkaline solution—it may be very beautifully coated with either tin or bismuth; though in these cases there might be considerable difficulty in getting the work done, owing to the neglect into which the art of electro-deposition, in its general aspect, and outside of certain prevalent processes, has unfortunately fallen.

The scissors, for the sake of diversity, might be bronzed, that is, coated with an alloy of tin and copper, by any of the processes which at one time were frequently and successfully employed. The bronze deposits, as well as that, of a golden colour, constituted by an alloy of copper, antimony and zinc, are, in our opinion, very beautiful, and improve, instead of deteriorating, by age. Lastly, the table knife might be coated either with silver or with antimony—metals which are not attacked by any of the vegetable acids. Nickel, it should be particularly observed, should never be used as a coating for articles which are to be brought into contact with all descriptions of food; since this metal does not resist the action of vegetable acids. Again, it is not advisable, from a sanitary point of view, to commence by depositing a coating of copper upon the steel; and, although the objection, from the same point of view, to a slight amalgamation of the surface may be more fanciful than real, we confess that we feel some satisfaction in the assurance that mercury, as well as copper, is entirely absent, and that the food can come into contact with no metal save iron or steel, silver or tin. We recently saw exhibited, at the Agricultural Hall, some specimens of cutlery coated with silver deposited directly on the steel; and although the particular process by which this result was obtained was stated to be a secret, we think that electro-metallurgists would find no insuperable difficulty in solving the same problem by various and, presumably, by other means. In fact, Mr. Alexander Watt, in his little work on Electro-Metallurgy, informs us that he obtained a strongly-adherent coating of silver upon steel simply by rubbing the latter with a sponge dipped in a solution of hyposulphite of silver in a slight excess of hyposulphite of soda. Such a coating, no doubt, would not of itself suffice, but it might well serve as a basis for a further deposit obtained by electrolysis. The knife, duly coated with silver, may, as was illustrated at the Agricultural Hall, be kept for any length of time stuck through a lemon, without being discoloured or chemically attacked. The same statement applies to the article when coated with antimony, in the first place from a cyanide bath and afterwards from Gore's depositing solution, of the potassio-tartrate of the metal dissolved in hydrocloric acid. The only objection to the coating with antimony, which may be made to resemble polished steel, is that the bath formed of the cyanide of the metal dissolved in cyanide of potassium offers a very high resistance to the passage of the current, and acts upon the anode imperfectly. A new antimony bath, of an alkaline character, for depositing the first coating upon iron or steel is, therefore, somewhat of a desideratum.

After the two sets of articles have been subjected to wear, say for six months, a comparison of them will, we think, speak volumes in favour of the electro-deposition processes.

By making any article of steel the anode in a solution of oxide of lead in caustic soda, a coating of peroxide of lead may be thrown down upon it, which, besides being highly ornamental, owing to the beautiful prismatic colours produced, by "interference," through its agency, affords considerable protection against rust. We are surprised that this process, which at one time afforded some most beautiful objects exhibited at scientific gatherings, has not come into more general use. We hear that on the continent it is now being used for the purpose of giving a very gorgeous appearance to tin-foil, intended to be employed for purposes of ornamentation.

In regard to the protection of larger articles constructed of wrought and cast iron, we think that some of the processes of electro-deposition might be made to enter into serious competition with the processes of oxidation, by the action of steam or of gases at a high temperature, devised by Dr. Barff and Mr. Bower. Some eight or ten years ago, the firm of Messrs. Turner and Allen, of Upper Thames-street, did some important work in the way of "bronzing," or, more accurately, coating with copper, large castings of iron. The "bronze" balustrade for the staircase of Sir David Sassoon's palace at Bombay was, we believe, produced by them in this way. At that time, the only bath employed for depositing copper upon iron was the solution of cyanide of copper in cyanide of potassium, which was not only, on so large a scale, unwholesome and expensive, but possessed the great disadvantage of requiring to be used at a high temperature. Since then, other alkaline solutions, free from all these disadvantages, have been found to give a better deposit than the cyanide bath. Moreover, the magneto-electric machine, a far less expensive source of electricity than batteries, is now available for electro-deposition. The commercial aspect of the problem has, therefore, completely changed; and the operations which were formerly carried on with doubtful pecuniary success might now be resumed with great advantage. But, however successful the deposition upon iron of copper—subsequently "toned" by means of salts of silver or platinum—might be from the point of view of ornamentation, it is—so far as our experience extends—inadequate for the protection of iron when exposed to the open air. In this case it is essential that the coating in actual contact with the iron should be of some metal electro-positive to it, or of some oxide which would not give rise to the production of a voltaic couple at any point where the coating might be worn or defective. The bronzing of the metal work on the Place de la Concorde at Paris, was performed by M. M. Oudry by first coating the iron with an impervious varnish, the surface of which was subsequently rendered conducting, and then coated with copper in the sulphate bath. But to our mind this process, in which certain difficulties are avoided rather than overcome, is far less satisfactory than would be the deposition of metal directly upon metal under conditions that would render the deposit an effectual preservative of the metal beneath. These conditions are well understood by all electricians; and a thoroughly preservative coating, which should be itself susceptible of superficial oxidation, whilst preserving a certain richness of aspect, is not, we think, beyond their reach.

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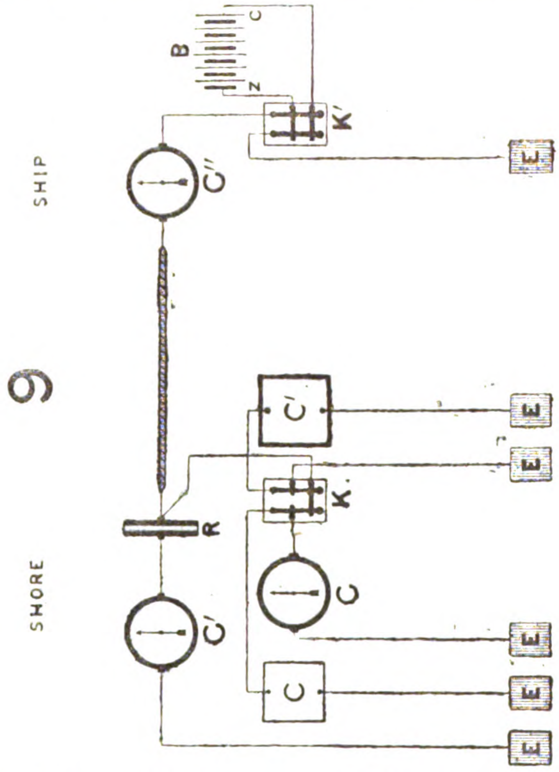
NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONTINUED FROM P. 260.)

V.

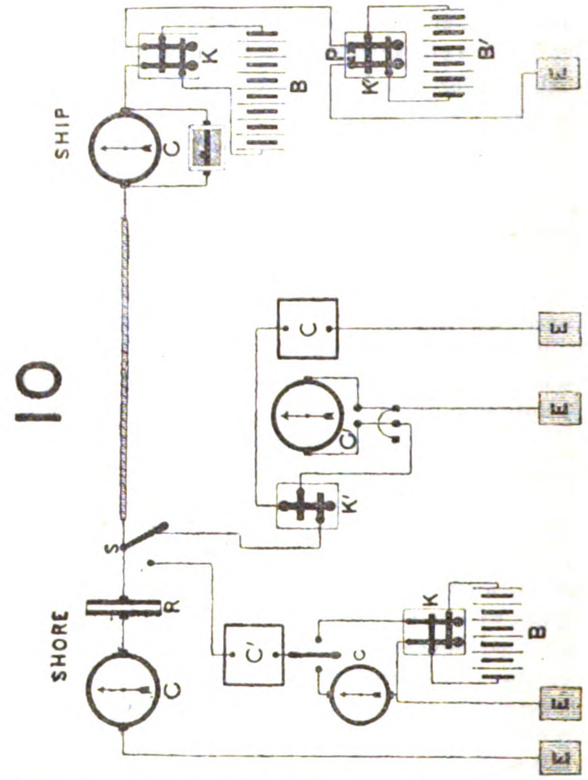
The arrangements which have been described are not those which were actually used for communicating between ship and shore during the laying of the 1866 Atlantic cable. Mr. Willoughby Smith informs us that, at the suggestion of Mr. Laws—who feared that by some accident the cable might be permanently connected to earth through one of the resistance coils C or $C_{\prime}$, and that thus the electricians on board ship might be led to conclude that a "fault" had become developed—he replaced these evils by two condensers of unequal capacity. This modification of the original plan is, historically, of very great importance; since it appears to have led directly to the use of condensers in Atlantic cable signalling. If we take C and $C_{\prime}$ to represent two *condensers*, instead of two resistance coils, connected respectively to the springs of the reversal key K, then diagram 9 will represent the modified arrangement.

It will be seen that on depressing the left-hand spring of K the condenser C would become charged from the cable, and that—this condenser being of smaller capacity than $C_{\prime}$—a signal corresponding to the *dot* of the Morse alphabet would be received



on the ship's receiving instrument $G_{\prime\prime}$. When the right-hand spring of K is similarly depressed, the condenser $C_{\prime}$ would become charged from the cable, and a signal corresponding to the Morse *dash* would then be received on $G_{\prime}$. Further it will be seen that when the left-hand spring of K is released, the condenser C will be discharged to earth through the galvanometer G, and that the deflection on this instrument will indicate the tension of the cable charge; thus constituting a check upon the indication on $G_{\prime}$, due to the passage through R of a small portion of this charge. The galvanometer G would also serve for the reception of signals transmitted from the ship by means of the key $K_{\prime}$, producing reversals from the ship's battery B. This plan, the most obvious disadvantage of which is the production of signals always on the same side of the zero upon the scale of the ship's galvanometer $G_{\prime\prime}$, and the consequent "wandering" of the beam of light, was only experimentally-tried before the Great Eastern started to lay the (1866) cable; and it was in its turn modified, as shown in diagram 10, according to the suggestion of Mr. Varley. But, so far as we are aware, it affords the first instance of the successful utilisation of condensers in experimentally signalling through a submarine cable. It should be observed, however, that—although one end of the cable is kept permanently insulated from earth—the principle of signalling by the effect of induction cannot be said to have received an application in this method of transmission. This in fact consists in "tapping" the charged cable by means of condensers, instead of momentarily connecting it to earth through high resistances. The essential difference in principle between the arrangements hitherto described and those which have now to be adverted to should be borne in mind by those who are desirous of studying or of recording the progress of submarine signalling.

Mr. Willoughby Smith informs us in his paper that, before the cable was laid, his plans had to be finally submitted to Messrs. Thompson and Varley as representing the Atlantic Telegraph Company. "The latter gentleman suggested that instead of using two condensers for speaking only one should be used, and that instead of charging it from the cable at stated intervals, it should be permanently attached to the conductor of the cable, and when required to speak to ship reversals from a local battery should be sent into the condenser, which would either increase or diminish the deflection on the ship galvanometer by induction; and to enable ship to speak to shore, the local battery should be replaced by a galvanometer, so that by sending reversals from a separate battery into the already charged cable the ship would either increase or diminish its potential, which would act inductively on the condenser, and cause deflections either to the right or left on the shore galvanometer. Mr. Varley's suggestion had the advantage over that of Mr. Laws, inasmuch as the signals were sharper and more distinct, and did not cause the beam of light to wander so far on the scale of the galvanometer."



In the system represented by diagram 10, the condenser $C_{\prime}$ was employed for receiving signals from, and also for transmitting signals to the ship. Here the arrangement for receiving—the use of a condenser, without the adjunct of a shunt constituted by a resistance possessing more or less electro-magnetic inertia, for obtaining signals by the effect of induction—appears to be altogether novel. The arrangement for transmission, from the end of the cable on shore, is that devised by Mr. Varley in 1862 as shown in diagram 5. It will be seen that when the switch connected to the condenser $C_{\prime}$ is moved to the right, for transmitting, (the switch S being at the same time moved to the left), the depression of the right-hand spring of the key K will communicate a *plus* charge to the condenser surfaces in connection with it, whilst the opposing surfaces, obtaining a *minus* charge by induction, send a *plus* charge into the cable. When, on the other hand, the left-hand spring of K is depressed, it connects the positive pole of the battery B to earth, and the condenser obtains from the opposite pole a *minus* charge; the opposing surfaces becoming *plus* by induction, and thus abstracting electricity from, or communicating a *minus* charge to the cable. The extra battery $B_{\prime}$ on board the ship was employed for signalling, by means of the key $K_{\prime}$ after the removal of a plug at P; and the signals on shore were received, by the effect of induction, from the condenser $C_{\prime\prime}$, the switch in connection with it being then moved to the left, for reception. The

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condenser C was, as before, used for "tapping" the charged cable; becoming charged by the depression of the key K_1, and discharged through the galvanometer G, by its release. This condenser served, therefore, for the "continuity" signal, and as a check on the indication of the shore galvanometer G in determining the tension of the shore end of the cable.

"The whole system," says Mr. Willoughby Smith, "worked remarkably well. During the fourteen days occupied in laying the cable from Ireland to Newfoundland, 164 messages in all were sent and received between the ship and the shore, containing 6,437 words, or 30,059 letters."

STRAY NOTES ON THE BRITISH ASSOCIATION MEETING.

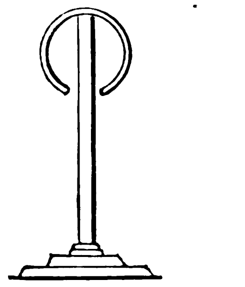
All the electrical papers read at this year's meeting have already appeared in this Journal, either in full, or in abstract. We shall now discuss shortly some of the leading features contained in these papers, and point out certain facts which appear not to have been noticed in the discussions on the papers.

One of the most striking of the electrical contributions was by Mr. J. E. H. Gordon, on secular changes in the specific inductive capacity of glass, in which it was experimentally shown that the specific inductive capacity of certain specimens of glass was found to be greater when measured in July and August of this year than when measured eighteen months ago. This is a result which, although novel, is not astonishing since it is known that glass, when new, undergoes slow contraction for a considerable time, as seen in the slow alteration of the freezing point in a newly-made thermometer. Now, if we assume that the absolute action of a piece of glass on the lines of electric induction is the same before and after contraction it would follow that a diminution of thickness would correspond with an apparent increase in the specific inductive capacity. But what was extremely surprising in the investigation, and which appears to have escaped the notice both of Mr. Gordon and of the meeting, were the results of the experiments he made to ascertain whether the lower specific inductive capacity obtained in the earlier measurements might not have been due to the glass being damper or less carefully cleaned than in the latter. For on damping a plate of glass he found its apparent specific inductive capacity to diminish. Now, if it be remembered that in the apparatus Mr. Gordon employs for measuring specific inductive capacity, the solid or liquid dielectrics do not touch the induction plates (see *Electrician* for March 15th, 1879, No. 17, Vol. II., p. 195) it follows that no leakage in the ordinary sense can occur. Damping a plate of glass can, apparently, only render it more conducting, more like a plate of metal, and the effect of this should be to *increase not diminish* the apparent capacity. For, imagine we have two metallic plates parallel to one another, and each of area a, separated by a space of air t in thickness, so as to form an air condenser, then the capacity of such a condenser will be $\frac{A}{4\pi t}$. Now, suppose a slice of the air between the two plates, parallel to them and of thickness t', removed and replaced by a good conductor like copper, then the capacity of the whole arrangement will be now $\frac{A}{4\pi(t-t')}$, which is a quantity greater than before. And so we might expect that anything which increases the conductivity of the dielectric must increase its specific inductive capacity. But, curiously enough, Mr. Gordon found with his apparatus, in which very rapidly reversed charges are employed, that the apparent specific inductive capacity of glass was always diminished by damping it.

Prof. Sylvanus Thompson brought forward an interesting experiment to prove that when a Bell's telephone was receiving from another Bell's telephone the vibrations were retarded in phase by half a vibration. This experiment consisted in suspending two such telephones, joined up in circuit, as two pendulums over two magnets, in such a way that the electric currents produced by the swinging of the one set up swinging of the other. But at the meeting it was not suggested as a criticism on this experiment that the rate of vibration of such a telephonic pendulum was, of course, incomparably slower than that of the iron disc when the instrument was used for speaking; consequently, the question of the time iron takes to become magnetised, which was of great import in the actual use of the telephone for speaking, was of no consequence in Dr. Thompson's pendulum experiment. Hence the ocular results of a half vibration retardation in phase obtained with the telephone pendulums formed little or no criterion, we consider, of what retardation actually occurs in the iron discs.

Dr. Lodge exhibited a reversing key (see *The Electrician* for September 20th, No. 18, p. 211) for electrometer work, which possesses so many good points that we are sure he will only thank us for pointing out what we consider are its defects; and, in order to do so, we may, for the benefit of the Committee of the British Association, which we observe has been appointed to devise a high resistance key, mention what seem to us to be the proper qualifications of such a key. 1. It must, of course, have nearly perfect insulation; as good, at any rate, as that of the quadrants themselves of the electrometer. 2. It must be screened by a metallic case from external induction. It must have no internal electromotive force. 4. Either both contacts made by the movement of the handle should take place simultaneously, or, for capacity measuring, at a given small interval of time. Now, we doubt whether condition No. 1 can be fulfilled, if the insulator is in a space not artificially dried, and artificial drying is very difficult in a box having openings as large as those necessarily used by Dr. Lodge, in consequence of the want of rigidity in his wires, and the motion of translation intentionally imparted to some of his terminal binding screws projecting through the holes. Dr. Lodge, in his arrangement, has perfectly fulfilled condition No. 2. As regards condition No. 3, we presume that ebonite which is untouched and not heated never develops an electromotive force; consequently, we hardly think ebonite need necessarily be excluded from an electrometer key, especially while this material is used to insulate the quadrant electrodes in the Thomson's electrometer itself.

One point with reference to leakage we would point out to the committee as worthy of notice, and one which we think should be experimentally examined. Starting with the idea that the actual amount of surface leakage along a rod depends not solely on the electromotive force at the two ends, as it would if it were conduction through a material of given resistance, but depends partly on this electromotive force and partly on the electric density at the ends of the rod, Professor Clerk Maxwell constructs all his insulated brass balls, &c., for the ordinary frictional electrical experiments in the following way, in order to obtain high insulation, a method which, by the bye, we believe, is not mentioned in any text-book:—The glass-supporting stem he passes through a hole in the brass ball at the bottom, and attaches it to the inside surface at the upper part of the ball (as in the figure), where the electric density is practically nought.



Now, does the same law hold for leakage when the electromotive force is only a few volts, or even a few hundred? We have ourselves measured the insulation of an ebonite stem damped in order to make the resistance measurable with a delicate galvanometer, but we found no difference whether the sides of the ball, the presence of which makes the density at the top of the stem nought, were removed or not. It is known that in a telegraph line the leakage increases more rapidly than the electromotive force. Is it then that the factor depending on the density is relatively insignificant for small electromotive forces, but becomes the more important for large? Possibly the British Association Committee, if they try the experiment, may find that the expression for the leakage current along a rod is something like

$$c = \frac{e + d\,e^s}{r},$$

where e is the electromotive force, d a small constant depending on the electric density at the end of the rod, s a moderately large exponent, and r the resistance. Of course, to avoid any apparent exception to Ohm's law, we may, if we like, regard the numerator as simply e, and assume r to be a function of e and of d.

The electrical feature at this year's meeting of the Association which attracted most attention was the lecture on "Electricity as a Motive Power." We have already in the leading article in our issue for September 13th, pointed out the bearing the electric transmission of energy must have in the economy of the manufacturing industries of places like Sheffield; but the chief point of the lecture, the result the author was led to, seems hitherto to have escaped discussion; for he says:—"A dynamo-electric machine, with a separate exciter, driven very fast with a steam

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engine, or with a stream of water, at high or low pressure, and sending by even quite a fine wire a small current to a distant electro-motor, also running very fast and magnetised by a separate exciter, is an economic arrangement for the transmission of power." Now, would not this arrangement, we ask, for transmitting power be economic in that there was no loss, simply because there was no energy transmitted, would, in fact, it not be useless as well as economic? This can only be settled by examining the formulæ. The waste of energy in heating wires equals per unit of time

$$\left(\frac{E - E'}{r}\right)^2 r,$$

where E, E′ are the electromotive forces respectively of the generator and motor and r the total resistance of the circuit. The work given out at the motor is per unit of time

$$\frac{E - E'}{r} \times E'.$$

Now, let $E - E'$ be very small, and E′ very large, then the expression for the waste of energy is very small, but not necessarily that for the useful work given out at the motor, since being a product of a very small and a very large factor this expression may have any value we please. Hence Mr. Ayrton's result, which at first sight appears startling, appears to be borne out by reasoning.

CABLE REPAIRING TWENTY-FOUR YEARS AGO IN A DUTCH SCHUYT.

BY F. C. WEBB.

(CONCLUDED FROM PAGE 269.)

For three months on and off were we employed in this delightful yacht on this charming coast, and at that pleasant time of year, the severe winter of 1854-5, of Crimean celebrity. We soon got over our sea sickness, and got quite used to the motion, and could walk the deck boldly in wooden sabots with our hands in our pockets.

The process repeated often was about as follows:—The captain of the schuyt had orders always to call me the moment he saw the slightest chance of fine weather, and to report matters to me every night. A bluff old fellow with large boots, a great woollen kind of gown, and sou'-wester, he used to come up at all hours of the night, sometimes with, "Bad weder, master, bad weder still. Plenty wind, plenty snow, plenty ice. *Maar*," with an apologetic shrug of his shoulders, "het is winter." Sometimes the weather would change in the night, and after I had turned in comfortably to a good bed, with the thermometer at zero, the windows covered with ice, and the walls of the room glistening, I was awoke by the entrance of a waiter with a Moderateur lamp, followed by the old Dutch skipper. "Fine weder, me think, master; wind come from the east; think possible can go to sea." Then I had to dress and scramble down over snow and salt water ice, some nine feet thick, to the waters edge, when I was carried through the water on the shoulders of one of the fishermen to the schuyt aground, but surrounded by the rising tide. Then came the misery of the hour's bumping on the beach, and the pounding against the bows of the ice-laden breakers, the half frozen water having the consistency of pea soup. At each bump the beams and deck seemed to bend down a good six inches. At last we went rolling off to our anchor, and would then stand out to sea, and beat up to where the big buoy rode some three miles away from our starting point. It took us sometimes a day to get there. Then perhaps it would come on to blow, perhaps before we could lift the ponderous buoy with the poor appliances that we could rig in so small a craft, and we would have to put back for the shore. The process of beaching these boats is peculiar. The sandy beach is flat, and the sea breaks far off. On coming into the breakers the craft is carried swiftly along, at an angle of forty-five degrees with the horizon, by each surf, as it rushes towards shore, ploughing up a great wave in front, and nearly burying her bows. And here we see the reason of their bluff bows, for if they were made fine forward they would simply plunge their bows under water altogether, and go down head first. When the surf is not too bad a grapnel is let go as the craft is rushing on towards the shore and the cable paid out, and when some of this is veered it is checked, and the boat begins to swing—that is, turn her head round towards the grapnel, now left astern. She is thus turning round in the midst of the breakers, and as she gets broadside on all have to hold fast, as she cants sidewise to each breaker which comes dashing at her side, enveloping her in spray and perhaps sweeping the deck. In another minute she is round head to sea, and then she touches with a big thump. But the operation is not yet complete. The tide sweeps along the coast, and if a grapnel was not quickly got ashore she would swing off to her sea grapnel, and thus be amongst the breakers again broadside on. A man ready jumps overboard, and, up to his armpits in water has a grapnel placed on his shoulder, with which he wades ashore, dragging the rope after him. In the summer they go in with their legs naked, but in the winter these men have a ponderous pair of boots and leather trousers all in one, which come up to close under the arms, and fasten with straps over their shoulders. To put these on requires considerable skill. They have to be wrinkled down to allow the feet to be got in, and then gradually worked and tugged till they are finally pulled up by getting a firm hold of the front part with the teeth and the head gradually stretched back. Thus a man literally may be said to pull his boots on with his teeth. To walk ashore in these requires considerable practice and skill, for as they are not very close fitting below the air gives buoyancy to their lower part, whilst the grapnel on the shoulder raises the centre of gravity of the whole. They are thus in a state of unstable equilibrium, and, the slightest want of balance, they would go over, and their feet come floating up.

Sometimes we were out for four days and nights at a time. We turned in "all standing" on to our straw-covered bunks—that is with every scrap of our day clothes on including pea-jackets, heavy overall boots, and sou'-westers, to keep ourselves warm; for, in spite of the fire, the water that oozed through the deck froze into icicles over our heads. One day when at work at the buoy we ran short of provisions, and were glad to make a meal off the mussels that had clung to the bottom of the iron buoy and its chain moorings. At last, after various trips, we got hold of the right telegraph cable near the buoy, and passing it over a sheave rigged up at the bows, and from thence to a sheave forward of the rigging, began to under-run the cable out to sea. At times, we could get our sails to help us, but at others we had to divide our men into watches, and each watch hauled at the cable. A cold dreary haul it was; the water dripping from the cable almost froze before it was over the side again.

The fishermen were simple-hearted men, and with a strong sense of humour in some. One particularly, named Kisch, was the life of the party. One night when he came below, after his two hours' hauling at the cable, he made the following impromptu lines:—

Von den kabel naar der *kooi* het is *mooi*,
Maar van de kooi naar de *kabel* het is *miserabel*,

which, freely translated, means—from the cable to the bunk is beautiful, but from the bunk to the cable is miserable.

The fare of these men consisted almost entirely of bread and potatoes, with the slightest dash of pork fat. At breakfast they eat white bread, with a very small piece of almost black bread, which they eat sparingly, like cheese, as a relish to the white bread. For dinner a huge dish of potatoes is placed in the middle of the party. A piece of fat bacon is placed in a frying pan and kept there till all the fat has run off into oil. This dripping is placed in a basin, the very minute portion of lean left being carefully divided amongst them, the share of each amounting to a moderate mouthful. After a long grace, which they reverently say with their heads hid in their sou'-westers, the captain begins by taking a potato on his fork and dipping it into the dripping, and eats it. The same operation is followed by each in succession until the huge pile disappears. A drop of snapps finishes the meal.

We were frequently driven from our work by bad weather, and had to begin again days after. At last one night we got out as far as the broken end, thirteen miles from the buoy. The wind, which was blowing from the east, was freshening, and by the time we got to the end the sea was breaking over us. Yet we were obliged, after buoying the end, to anchor and hold on, as the lee tide had made, and had we attempted to make for the shore we should have been swept away miles to the westward. There was nothing for it but to ride it out. The water she shipped froze until there was a sloping mass of ice from the forward gunwale to the deck, and adding such weight that she was some six inches down by the head. The whole deck was a sheet of ice, the sails and ropes and blocks being nearly frozen into a helpless mass. When the weather tide made the ship was, in fact, barely manageable. She would scarcely steer on account of her trim; it was almost impossible to set the sail, and, the deck being a mass of ice, it was impossible to stand without holding on. At last we got into the land, but the captain of the schuyt declared he had never been in greater danger of losing his craft.

At one time it became most difficult to preserve the craft on the beach, for the salt water ice had so accumulated that it formed a kind of cliff nine to ten feet high, outside which the schuyt had to be kept, and against which, on some nights, it was difficult to keep her from being pounded to pieces. As the spring

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came, the fresh-water ice from the Rhine used to come floating down in floes, making a noise like the cackling of a flock of geese. One day, when at anchor, the old Dutch captain, seeing some ice bearing down on us, rushed to the hatch covers, seized one, and, bending on a rope, lowered it over the bows just in time to take the blow from the ice, which stove in the hatch-cover. Had it struck the bows it would have sunk us, as the skin of these craft is barely an inch think, as the old captain remarked. At last, after three months of this pleasant work, we spliced the cable and returned to Schweningen with the broken ends in triumph at our masthead.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The ordinary general meeting of the shareholders of this Company was held on Tuesday, October 28th, at the City Terminus Hotel, under the presidency of Viscount Monck, the chairman.

Mr. Richard Collett, the secretary, having read the notice convening the meeting, and the minutes of the last general meeting, which were approved by the present meeting, and signed as correct by the chairman, the directors' report, which appeared in *The Electrician* of last week, was taken as read.

The Chairman, in moving the adoption of the report, said that he should not have to detain them with a long speech. The object which his colleagues and himself had always had in view was to frame the accounts and reports of the Company in a perfectly plain and intelligible form, and, to facilitate comparison being made between one year and another, or half a year with half a year, never to alter the form of the accounts. That being the case, he presumed that any gentleman who took the trouble to look through the accounts for the past half year, and compare them with those of the previous half year would be in a position to judge of the condition of the enterprise quite as well from the exercise of his own intelligence as from any remarks that he was capable of making. They would observe that the receipts for the past half year had been £75,083 in round figures. They were about £10,000 larger than the receipts of the previous half year, but he had told them more than once that it was not fair to compare successive half years with one another. The first half of the year was always better for their traffic than the second half, so that, comparing the half year under consideration—the half year to the 30th June last—with the corresponding period of the previous year, they would find that there was an increase of only £5,000. Owing to the war at the Cape they had brought a considerable amount of news from Madeira and St. Vincent, and the amount by which this half year exceeded the receipts of the corresponding half year of 1878 was almost precisely identical with the additional traffic they had derived through the war. That would appear to show that there had been no increase in the normal traffic of the line, but he was happy to say that that was not absolutely the case. There was an increase of about 15 per cent. in the messages, but there was the unfortunate agreement with the Western and Brazilian Company, who were perpetually in a position incapacitating them from carrying their traffic. Their agreement with the Western and Brazilian Company was to exchange a proportion of their whole traffic against a proportion of the Western and Brazilian Company's whole traffic. The result was, as he need hardly state, that if the Western and Brazilian Company were not carrying the traffic this Company paid them hard cash and received nothing in return, and it was not merely that, but something worse, because when the Western and Brazilian Company were out of order and incapable of carrying their own traffic, they were obliged to send it by the Brazilian land lines and pay for it, and this Company, under the agreement, had to pay a portion of these expenses. This was undoubtedly an unfortunate state of things, but he hoped, with the assistance of their legal adviser, that they would be able to do something at all events to mitigate the evils of the agreement. If they could get rid of it they would have a fair increase in their traffic from year to year. So much for their receipts. As to their expenses, they could, unlike the receipts, be fairly compared with the expenses of the previous half year, and they showed a decrease of £912, consisting of £214 in the general expenses in London and at the stations, and a sum of £698 decrease in items of extraordinary expenditure for new shore ends of cable at Lisbon, &c. There was an absolute saving of £214 in their normal expenses, and he thought that that showed that those who looked after them exercised sufficient vigilance in the shareholders' interests. He might add that the per centage of their working expenses to earnings—including everything—was only 15½ per cent. Their cables were working well; they were in complete order and they were carrying the traffic as well as it possibly could be carried. With regard to their reserve fund, it was growing, but he would anticipate any observations which might be made on the subject by saying that until it reached a sum much larger than it was at present he was afraid it would be the height of imprudence on the part of those who were guiding the concern not to lay by every available shilling after paying a dividend of 5 per cent. [hear, hear]. He was very glad to hear that expression of their approbation, for it was an opinion which he held so strongly that, if it was dissented from by the great body of the shareholders, he should feel it his bounden duty to relinquish the position in the Company which he had held from its inception to some person who could conscientiously carry out the views of the majority of the shareholders. He concluded by moving the adoption of the report and accounts, and the declaration of a dividend of 2s. 6d. per share, free of income tax, making a total dividend of 5 per cent. for the year ending the 30th of June, 1879.

Sir James Anderson seconded the motion, and endorsed all that the Chairman had said with reference to the reserve fund.

In the discussion which ensued several shareholders took part, some of whom spoke strongly in favour of increasing the dividend, and not transferring so much to the reserve fund, which they contended was sufficient now with the interest accuring on it for the purposes of the Company. Other gentlemen, however, were of an opposite opinion, and upheld the policy of the directors in increasing the reserve fund. An amendment was moved to the effect that the present dividend should be 4s. 6d. instead of 2s. 6d. per share, making the dividend 6 per cent. instead of 5 per cent. for the year. Another shareholder thought it would be satisfactory both to the directors and the shareholders if a bonus of 1s. per share at the end of the year were declared. Mr. Spicer thought, as the amendment was out of order, that a resolution should be passed to the effect that the amount to be carried to the reserve fund should not exceed at the present time a certain amount.

Mr. Burt, the Company's solicitor, said that both the amendment and Mr. Spicer's suggested resolution would be out of order according to the articles of association, from which he quoted in verification of his statement.

Mr. John Newton said that the difficulty could be got over by Mr. Spicer moving a resolution recommending the board to do such and such a thing.

Mr. Spicer, acting on this suggestion, moved "That the board be requested not to add more than £30,000 per annum to the reserve fund from this time." He agreed to the resolution being considered at the close of the ordinary business.

The Chairman, in reply, after answering two remarks of a personal nature, said the root of the whole matter lay in the question which had been asked, "What is the purpose of the reserve fund?" In order to understand that in the sense in which he looked on it they must consider what is a cable? A cable was a little wire enclosed with gutta percha lying at the bottom of the sea. If they had not their own experience they had the experience of other companies as to the "life" of a cable. The Anglo-American Telegraph Company had at that moment two cables at the bottom of the sea not working, and they were respectively only nine and ten years old when they ceased working. That company had made several efforts to recover those cables, and had incurred considerable expense, but to no purpose, and the conclusion they had all arrived at, based on those attempts, was that if they could get a cable laid on a good bottom it was very doubtful whether it might not last 50 or 100 years; but the bottom of the sea was as irregular as the surface of the earth, and their experience was that if they got a cable on a bad bottom, and it broke in deep water, after eight or ten years it was irrecoverable. The Company had between Lisbon and Pernambuco about 3,800 miles of cable, and if the cable or any part of it broke their income was suspended immediately. They had now been working five years. It might be said that if the cable broke they could raise money to replace it, even if they had not sufficient reserve fund for the purpose, but to raise money they would have to go into the money market, and what security had they to offer? If their cable were broken they had absolutely none. They had 3,800 miles of cable, which was more than twice the length of the cable between Ireland and Newfoundland, which was the American cable; and for the replacement of a cable 1,800 miles long all the Atlantic companies—the North American Atlantic companies—thought it necessary to lay by £50,000 a year. It therefore seemed to him, judging from the experience of those companies, that this Company was putting by a miserably inadequate sum to the reserve fund. They would now see what was the purpose of the reserve fund—to replace their property in the event, the very possible event, of any portion or section of this cable breaking, in order not to lose altogether the capital they had invested in the concern. That was the object of a reserve fund, and he might say, in answer to a question, that it was also applicable to equalising their dividends. The reserve fund was as much the shareholders' property as any portion of the undertaking. The laying of a second cable had not entered their minds, and his own feeling was that it was best to defer as long as possible the laying of a second cable on account of the deterioration which took place. As to the spare cable in stock, they would be glad to dispose of it. It was the surplus cable that remained from the laying of the original cable. He then put the motion, and declared it carried with three dissentients.

The retiring directors—Mr. Frederick Youle and Sir James Anderson—were then re-elected, as were also the retiring auditors, Mr. Henry Dever and Mr. John Gane.

The Chairman then submitted Mr. Spicer's motion, and stated that 21 voted for it, and 22 against it; but the Board did not vote, and he had a much larger number of votes "in his pocket." He formally declared that the resolution was lost.

The proceedings then terminated with a vote of thanks to the Chairman and Directors.

RECENT PATENTS.

454. Electric Lighting, *R. W. H. P. Higgs.—Dated 5th February*, 1879. —*(Not proceeded with.)* 4d.

This relates to a lamp which consists of a base, upon which is mounted an electro-magnet with vibrating armature and a standard. The vibrating armature carries a block of carbon or other material, and to the standard is attached a tube in which slides a rod of carbon or other material. This rod, upon passage of a suitable electric current becomes incandescent between the bottom of the tube and where it is momentarily in connection with the block. Between the end of the rod and the block a voltaic arc and the extra spark appear. The rod is forced downwards by its own weight, aided, if needed, by a weight, and it is prevented falling too freely by a counterpoised friction arm. The tube can be adjusted to any required distance from the block.

477. Galvanic Batteries, *T. Slater.—Dated 6th February*, 1879. 6d.

This consists in using metal nickel in combination with flat or cylindrical plates of carbon, platinum, or other suitable metal in single or double fluids as excitants, which may be any of the well known solvents of nickel.

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485. SOUNDERS FOR TELEGRAPHIC PURPOSES, *J. R. Edwards.—Dated 7th February*, 1879.—(*Not proceeded with.*) 2*d*.

The single form of the instruments consists of a stand carrying a permanent magnet, preferably of horseshoe form, one pole being made longer than the other, and placed uppermost. Below this long pole is fixed an electro-magnet having a soft iron core passing through the long pole of the permanent magnet, and magnetised by it, and made in two parts capable of being adjusted at any required distance from each other by a screw or its equivalent carried on a bracket on the long pole of the magnet or otherwise. Below the shorter poles of the permanent magnet is placed another electro-magnet with an iron core capable of being adjusted in regard to its height above the coil. A soft iron armature carrying at its outer end the brass hammer for striking the sounding plate, bell, or drum, is hinged or pivotted to the short pole of the permanent magnet, and magnetised by it.

679. MARINERS' COMPASS, *Sir W. Thompson, Kt.—Dated 20th February*. 1879. 6*d*.

This consists, first, in supporting the bowl by means of an elastic ring, whether with the intervention of a rigid gimbal ring or not; secondly, in cases where a rigid gimbal ring is employed, the mounting of the elastic ring upon balls and sockets, and the hanging of the rigid gimbal ring from the elastic ring (or in cases where the elastic ring is used as a gimbal ring then the hanging of the elastic ring from fixed hooks) by stirrups, chains, and saddle pieces; thirdly, the arrangement of receptacles for containing the magnets for correcting the semicircular error of the compass.

684. APPARATUS FOR PRODUCING LIGHT BY ELECTRICITY, *M. A. Wier.—Dated 20th February*, 1879. 6*d*.

Powdered substances are caused to pass through or over the field of electric action between two conductors or electrodes, and in order to enable the latter to act upon the same particles of powder any given number of times during their passage, so as to spread the light over a large surface and thereby diminish its intensity, the conductors or electrodes are arranged in pairs parallel to but separated from each other by an extremely small distance, and then by folding these conductors upon each other or winding them in pairs, produce an extended surface forming a kind of grating, each alternate bar of which is part of one electrode and the next bar part of the other. The grains of powder, as they come in contact with the alternating conductors, make and break contact several times before quitting the field of the electric action.

740. ELECTRIC LAMPS, *F. Mori, C. E. Hallewell, W. Milner, and W Griffin.—Dated 24th February*, 1879. 6*d*.

For a lamp designed to carry four pairs of carbons to be successively burnt as the preceding pair is consumed, a circular glass disc is employed, and has in its centre an upright pillar with four branches to carry one of the carbons with each pair, the other carbons being supported by separate brackets fixed to the disc. The pillar is connected with one conducting wire, so that the candles carried by it are always ready to receive and transmit the current, whilst the other candles may be brought into the circuit by a commutator, consisting of a disc with eight branches mounted upon the central pillar. Four of the branches transmit the current to the four outer candles by coming in contact with studs connected therewith. The commutator is placed on the stud in connection with the outer candle of the first pair, and kept there by a spring until this pair is consumed, when the spring is released by the fusion of a wire, allowing the commutator to pass to the stud of the next pair of candles, and so on until the whole of the carbons are consumed.

749.—GALVANO-MAGNETO-DYNAMO-ELECTRIC MACHINE, *C. Dubos.—Dated 25th February*, 1879. 6*d*.

The electro-magnets are made in the form of double rings of soft cast iron having segmental collars on them, between each pair of which insulated wire is coiled transversely to the circumference of the ring over the double annular cores, each coil being so wound or so connected in the circuit of the machine that the electrical current through its coil is the opposite direction to that in the next coil on each side of it. Within this annular electro-magnet is caused to rotate a disc, having fixed round its periphery a number of coils of insulated wire equivalent to the number of polar segments of the ring, so that each coil in passing through each of the polar fields of these segments has alternating electrical currents induced in its wire. These currents are led to a commutator, where they are collected to be passed through the external circuit as well as through the coils of the ring.

781. ELECTRIC TELEGRAPHS, *E. A. Cowper.—Dated 26th February*, 1879. —(*Not proceeded with.*) 2*d*.

This relates to improvements on patent No. 2,385, dated 15th June, 1878. A single movable soft iron bar, tube, or needle is employed, which is connected to and is in line with or parallel to the pen or style, being suspended between two fixed electro-magnets or two sets of such magnets situated at right angles or other angle to each other, through the coils of which electro-magnets the varying currents of the two circuits are made to pass.

783. OBTAINING ELECTRIC LIGHT, *G. P. Harding.—Dated 26th February*, 1879. 6*d*.

An intense light is obtained from a surface of lime or other refractory earth heated by electricity. A carbon pencil is enclosed in a sheath of lime and an electric current passed through it, causing both to become highly heated.

792. ELECTRIC TELEGRAPHS, *Sir C. T. Bright, Kt.—Dated 27th February*, 1879. 6*d*.

In the receiving apparatus the opposing force of a spring or other retarding agent is withdrawn by causing the current to act simultaneously upon an auxiliary armature, which is linked or connected to the signalling magnet. The latter may either give signals to the eye or ear, or may actuate a local circuit comprising a recording or type-printing instrument.

PARABOLIC, CONIC, CONVEX, CONCAVE, AND EVERY DESCRIPTION OF REFLECTORS FOR ELECTRIC, LIME, OR MAGNESIUM LIGHT.—Chappuis, Manufacturer, 69, Fleet-street.—[ADVT.]

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 29.		Business Done Week Ending Oct. 29. Highest.	Lowest.
Anglo-American Ordinary	55,	½	56	55½
Do. "B"	80¾,	1¼	82	81
Do. "A"	31,	½	32½	31½
Brazilian	7 3-16,	7 5-16	7 5-16	7
Cuba	7¾,	8¼	8	8
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	10¾,	11¼	11¼	10¾
Direct United States	10½,	¾	11	10¾
Eastern	8 1-16,	3-16	8¼	7 15-16
Do. Six per Cent. Debenture	103,	6	104	104
Do. Five per Cent. do	103,	5	104	103
Do. Six per Cent. Preference	12 1-16,	3-16	12¼	12⅛
Eastern Extension	8 5-16,	7-16	8 7-16	8 1-16
Do. Six per Cent. Deb.	106,	9	109	107½
German Union	7½,	¾	—	—
Globe Telegraph and Trust	4 15-16,	5 1-16	5 1-16	4 15-16
Do. Six per Cent. Preference	11 1-16,	3-16	11¼	11
Great Northern	8½,	¾	8¾	8 9-16
Indo-European	22½,	3½	23	22½
Mediterranean Extension	2¾,	3¼	—	—
Do. Eight per Cent. Preference	9¾,	10¼	—	—
Reuter's	9,	10	10	10
Submarine	225,	30	—	—
West India and Panama	1¼,	½	1⅝	1⅜
Do. Six per Cent. Preference	7½,	8	8⅛	7⅝
Western and Brazilian	3½,	¾	3½	3⅜
West. Union Seven per Ct. 1st Mt.	123,	8	123	123
Do. Six per Cent. Sterling	105,	7	—	—

TRAFFIC RECEIPTS FOR SEPTEMBER, 1879.

Companies.	Sept. 1879.	Sept. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,463	537	—
Direct Spanish Telegraph Company	1,121	1,048	73	—
Direct United States Telegraph Company	21,080 estd.	—	—	—
Eastern Telegraph Company	39,369	38,169	1,200	—
Eastern Extension Telegraph Company	26,980	22,151	4,829	—
Great Northern Telegraph Company	18,775	—	—	—
Submarine Telegraph Company	11,911	9,661	2,250	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	1,200	—	—	—

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NOTES.

The Late Electric Lighting Company.—The apparatus belonging to this company was sold by auction last week. The sale took place by order of the official liquidator.

Telegraph Construction and Maintenance Company.—The ss. Kangaroo, belonging to this Company, will sail next week with a short cable for the New Zealand Government.

Exhibition at Redruth.—At the annual exhibition of the Cornwall Mining Institute in the Druid's Hall, Redruth, we noticed, among other things, André's electric lamp, and Edison's loud speaking telephone.

Telephonic Exchanges.—We are glad to hear that the system of telephonic exchange is about to be practically tried in Sheffield. A number of firms have given in their names as subscribers, and wires will be laid forthwith.

South Australia.—The Marine Board has decided to establish the electric light at Cape Northumberland. The estimated cost is £20,000. Oil lamps can be used as an alternative light in case of failure with the electric apparatus.

The French Atlantic Cable.—Messrs. Siemens Brothers have received a telegram from the steamship Faraday through the French Atlantic Cable, dated November 3, stating that, "having successfully completed present operations, she is proceeding to Halifax."

The Society of Telegraph Engineers.—The next ordinary meeting of this society will be held at the Institute of Civil Engineers on Wednesday, November 12, when a paper by J. R. Preece, Esq., on "The Telegraph from Teheran to Bushire" will be read.

Natural Science.—We notice that a new edition of Miss Buckley's "Short History of Natural Science" has just been published. The work is exceedingly interesting, and appeals to the general, as well as the scientific reader. The book is published by E. Stanford, Charing-cross.

Egypt.—Messrs. T. Cook and Son state that the Khedive Administration has appointed English-speaking telegraph operators to the offices of Assioob, Belanah Luxor, and Assonan, so that in future there need be no fear of the mis-interpretation or mis-sending of telegrams to and from these Nile stations.

The Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company (Limited) during the month of October was 2,949, estimated to produce £3,000, against 2,744 messages, producing £2,835, in the corresponding month of last year. The traffic receipts for the month of August, estimated at 2,300, realised £2,557.

Extension in the Use of Telephones.—We are informed that the use of telephones is extending very rapidly. The instruments have been introduced at Windsor Castle and Buckingham Palace, at some of the most important metropolitan railway termini — for example, the Great Western, South Eastern, Midland, &c.—and are being largely supplied to private mansions.

The Cape Cable.—The ss. Scotia, belonging to the Telegraph Construction and Maintenance Company, has taken on board the remaining portion of the Cape cable, and leaves the Thames this morning for Aden. The laying of the cable will be completed early next month. In order to obtain the best course for the bed of the cable no less than 118 soundings have been made between Zanzibar and Aden.

Professor James Clerk Maxwell.—We regret to have to announce the death of Professor Clerk Maxwell, which took place on Wednesday, Nov. 5, at his residence in Scroope-terrace, Cambridge. We hope in our next issue to give details as to the work of the late professor, meanwhile we may say he graduated as Second Wrangler in 1854, Mr. Routh being Senior, while both were bracketed as equal in the contest for Smith's Prize. His loss will be severely felt in all scientific circles, both at home and on the Continent.

The Electric Light.—Some experiments have been made with this mode of conveying messages, during last week and this week, by the Royal Engineers. There are five machines erected at the back of the School of Military Engineering on a commanding battery, and the powerful long-distance sights enable reading to be performed at a distance of five miles. By this means parties of Royal Engineers have been greatly assisted in drawing out lines of fortification on the Lines at midnight. It is also used for signalling and other purposes; crowds of people have witnessed the operations from the road between Old and New Brompton.

Report of the British Association.—We are glad to find the effort to issue the report early after the meeting has been so successful. The volume containing the reports and abstracts of papers read at the Sheffield meeting in August is now ready. We have previously directed attention to the papers on electrical subjects, but these of course form an exceedingly small portion of the book, and scientific men will find herein a large amount of valuable information. Would it not be possible to include, in future issues, the evening and general lectures delivered during the meeting?

Electricity and Silkworms.—A learned Japanese has discovered, to his own satisfaction, that silkworms, which, as is generally known, are subject to many mysterious diseases, suffer from a defect of electrical current. We learn from Japan that one Sekimidzu Harukichi, of Fukuda Mura Takaza Gori, Saigami, has invented an electric machine, by means of which weak silkworms, treated to a current, are made strong and healthy. He has already experimented with his invention in Kurami Mura, and finding that it is

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just the thing required, has applied for permission to vend it publicly. *Caveat emptor!*

The Royal Engineers and Telegraphy.—All officers of Royal Engineers and such non-commissioned officers and men of the corps as may be selected will in future be required to go through a course of instruction in telegraphy and in the methods of constructing telegraph lines, in the School of Military Engineering, Chatham, and a certain proportion of them will also be attached for duty to the companies of Royal Engineers employed in the Postal Telegraph Service. At stations where permanent military signal and telegraph stations are established, an Engineer officer is, when practicable, to be placed in charge of them, under the commanding Royal Engineer, except at those stations where the working of the military telegraph lines has been entrusted to the telegraph companies of the Royal Engineers under the General Post Office, in which case the signalling arrangements only will be under that officer. At stations where the working and maintenance of the military telegraph has been entrusted to the telegraph companies of the Royal Engineers, the commanding Royal Engineer, in conjunction with the officer commanding those companies, will draft such regulations as local circumstances may require, and submit them to the general officer commanding, who, if he concurs, will submit them for the approval of the Secretary of State for War.

Illuminating Steam.—On the evening of October 31st, some interesting experiments, illustrative of a new method of signalling at sea by illumination of steam, were tried on board the Trinity yacht Galatea, lying off Trinity Wharf, Captain Ladd, one of the Trinity Brethren, and Mr. Douglas, the engineer, were present. Colonel Ramstedt, a Swedish gentleman, formerly of the Russian navy, is the inventor of the process, which is very simple, and consists merely in reflecting light from the escaping steam, or on a special body of steam. The inventor uses a tinned iron dish, in the bottom of which is a trough, in which he burns strontium, and the receptacle is fitted with a lid, acting as a reflector, by which the light is thrown on the steam steadily or in flashes, as may be desired, the light being rendered visible in falling on the globules of water of which the steam vapour is composed. By this process the steam becomes a luminous mass, varying in colour according to the substances used in combustion. The light was very distinctly seen from the pier at the Blackwall Railway Station, a quarter of a mile distant, but that was hardly a trying test, and, besides, the air was not very largely charged with moisture, which is the great difficulty in the way of sigalling. The question to be settled is whether the light thus produced is sufficient in intensity to carry farther than the present signals, which, again, are being superseded by the electric light in some cases. It was understood that persons were stationed a mile and a half from the Galatea last night with a view to report to the Trinity authorities on the power of Colonel Ramstedt's process.

The Electric Light.—The merits of the electric light are demonstrating themselves, and attracting attention where an efficient and economical lighting agent is much needed. We observe that during the recent trial trip of the new steel ship Mendoza, built for the Pacific Steam Navigation Company by Messrs. Napier and Sons, of Glasgow, an interesting trial of the light was made in the saloon of that vessel. A portion of Messrs. Napier's works has been for some time past illuminated by means of a Gramme machine and Serrin lamp, and at the request of the company present at the trial trip the apparatus was fitted temporarily on board, and an electric light produced. It is stated that the saloon was very successfully lighted by this means. This is, we believe, the first example of the electric light being used on board a merchant steamer for interior lighting, and there is no doubt that this first experiment will be followed by others of a similar nature, having for their object a safer, cleaner, and more economical lighting than is at present obtained by the use of oil lamps and candles in the saloons and cabins of our ocean steamships. Many forms of small electric lights capable of great subdivision are being brought forward, and it is claimed by those interested in the promotion of the electric light that by one system no less than ten lights of about 80-candle power each can be worked by a small Gramme machine similar to that which produced the electric current for the larger light used on the trial trip of the Mendoza. A couple of small Gramme machines, therefore, capable of supplying twenty electric lights, of the aggregate illuminating power of about 1,600 candles, would appear to be a very desirable acquisition to a large ocean steamship. At any rate, with the facts already before us, the subject will, no doubt, be further inquired into, as it well deserves to be. We are informed that the British Electric Light Company are giving considerable attention to this branch of lighting, and are engaged in constructing various types of Gramme machines with a view to obtaining the best results in this direction.—*Globe.*

Society of Arts.—The programme of this Society for its 126th Session has just been issued. It gives a list of the Papers and Lectures for the Session, so far as they have been arranged. The following are the papers to be read at the evening meetings previous to Christmas:—November 26—"Suggestions for Dealing with the Sewage of London," by Major-General H. Y. D. Scott, C.B., F.R.S. December 3—"Apprenticeship: Scientific and Unscientific," by Sylvanus P. Thompson, D.Sc., Professor of Applied Physics at University College, Bristol. December 10—"Art Vestiges in Afghanistan; the Results of Some Recent Explorations in the Jellalabad Valley," by William Simpson. December 17—"The Panama Canal," by Captain Bedford Pim, R.N., M.P. The dates of the Papers after Christmas are not announced, but the following are among the subjects to be treated:—"Domestic Poisons," by Henry Carr; "Gas Furnaces and Kilns for Burning Pottery," by Herbert Guthrie, C.E.; "The Utilisation of Slag," by Charles Wood; "Art in Japan," by C. Pfoundes; "The Trade and Commerce of the Yenisei," by Henry Seebohm; "Modern Autographic Printing Processes," by Thomas Bolas, F.C.S.; "The History of the Art of Bookbinding," by Henry B. Wheatley, F.S.A.; "Art Ironwork," by J. W. Singer; "The History of Musical Pitch," by A. J. Ellis, F.R.S.; "The Recent History of Explosive Agents," by Professor Abel, C.B., F.R.S.; "Ireland and its Resources," by C. G. W. Lock; "The Future of Epping Forest," by William Paul, F.L.S. Three courses of "Cantor Lectures" are to be given. The First Course is by Dr. Charles Graham, F.C.S., F.I.C., Professor of Chemical Technology at University College, London, on "The Chemistry of Bread and Bread-making." The Second on the "Manufacture of India rubber and Gutta percha," by Thomas Bolas, F.C.S. The Third by R. W. Edis, F.S.A., on "Art Decoration and Furniture." The first meeting of the Session will be held on the 19th inst., when the Opening Address will be delivered by Lord Alfred S. Churchill, Chairman of the Council.

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AN ATTEMPT AT A SYSTEMATIC CLASSIFICATION OF THE VARIOUS FORMS OF ENERGY.

[This Paper by Dr. O. J. Lodge appeared in the *Phil. Mag.* The discussion of the question of energy in every form is so interesting that we reprint the Paper.—Ed. *E.*]

1. Every action which takes place between two bodies* is of the nature of a *stress*. A stress consists of two equal opposite forces (called action and reaction, or force and anti-force), one of them exerted by the one body, and the other by the other; and it is impossible for one force to be exerted without the other.

2. Whenever a body exerting a force moves in the sense of the force it exerts, it is said to do *work*†; and whenever a body exerting a force moves in the sense opposite to that of the force it exerts, it is said to have work done upon it, or to do anti-work, the quantity of the work being measured in each case by the product of the force into the distance moved through in its own direction.

3. Whenever two bodies exert a stress on each other, they are in contact; and if they move, they move together over the same distance‡: hence, since the force equals the anti-force, the work done by the one in any movement is equal to the anti-work done by the other.

4. The working-power§ of a body is measured by the average force it can exert, multiplied by the *range* or distance through which it can exert it. The working-power of a body may be increased or diminished by increasing or diminishing either the force, or its range, or both; and it must remain dormant so long as external circumstances do not allow it to exert a force through a distance.

5. Whenever work is done *upon* a body, an effect is produced in it, which is found to increase the working power of that body (by an amount not greater than the work done); hence this effect is called *energy*, and it is measured by the quantity of work done in producing it||. Whenever work is done *by* a body, *i.e.* antiwork done on it, its working-power is found to be diminished (to at least the extent of the work done), and it is said to have lost energy—the energy lost being measured, as before, by the anti-work done in destroying it.

6. But in every action taking place between two bodies the work is equal to the anti-work (§ 3); hence the energy gained by the first body is equal to the energy lost by the second; or, on the whole, energy is neither produced nor destroyed but is simply transferred from the second body to the first. (Remember footnote to § 1.)

To summarise then:—Work creates energy; anti-work destroys it; so both together simply transfer it. Or, in other words, the transferrence of energy requires a stress to act through a distance, and involves therefore two equal opposite works. If it were possible to obtain a force without its anti-force, or if it were possible for two bodies exerting stress on one another to move over unequal distances (§ 3), when it would be possible to obtain work without the anti-work, and thus to get a source of new energy (technically called the Perpetual Motion); but, as a fact of experience, it is not possible.

7. When work is done upon a body, different kinds of effects can be produced, depending both on the nature of the body and on the way in which the forces doing the work are applied to it; and these constitute the different *forms* of energy.

8. We can proceed to classify the forms of energy by first of all considering how the effects produced depend upon the forces applied to the body.

If these forces have no resultant (*i.e.* if they are in equilibrium), the body will be *strained*, and will exert a corresponding stress.

If the forces have a resultant, the body will be *moved**; and the motion will be either a translation or a rotation, or both, according as the forces can be reduced to a single finite resultant, a resultant zero at infinity, or to both combined.

Similarly, the strain may be analysed into compression, elongation, and shear, or a combination of them, according to the way the forces act; but this division does not appear to be of much use for our present purpose.

All these effects are forms of energy, because the working-power of the body in which they are produced is in general increased; *i. e.* the body is rendered capable of doing work as soon as the proper condition is supplied. (See § 4.)

Thus a steadily strained elastic body is exerting force or pressure; but its point of application is stationary: allow it to move, and work is immediately done. A body in free motion is passing through space, but it is not exerting any force; supply a resistance, and work is immediately done.

9. Energy, therefore, has two principal forms:—

(1) The free motion of bodies relatively to one another;

(2) The separation of bodies from one another against stress.

And to these may be added for convenience the rapid alternation from one form to the other, called vibration.

10. The two fundamental forms of energy correspond to the two factors in the produce work.† A body exerting force possesses energy, and a body moving through space possesses energy; but a body is not doing work unless it is *both* exerting force *and* moving through space.

The energy possessed by matter in motion is called *Kinetic*. The energy possessed by matter exerting force is called *Potential*. It might with great propriety be called *Dynamic* energy; and it has been very conveniently called *Static* energy‡, in opposition to kinetic. Of the two factors F and *s*, then, in the product work, kinetic energy corresponds to *s*; there is motion through space, but no force: potential energy corresponds to F; there is force, but no motion.

11. Whenever work is being done, both factors must be present—that is, both kinetic and potential energy; and the energy is always passing from one of these forms into the other while the work is being done. For if the motion of a body is *with* the force which acts upon it, its speed must increase; and if the motion is *against* the force, the speed must decrease; while in the first case the available distance through which the force can act, or the *range* of the force, is decreasing, in the second increasing.

12. The groups into which the forms of energy have been arranged (§ 8)—viz., strain, rotation, translation, and vibration—may now be subdivided further, by considering how the effects produced when work is done upon a body depend upon its nature and size.

A convenient division of bodies, according to size, will be—

1st. Masses comparable in size with the human body; which may be called ordinary masses.

2nd. Masses incomparably larger, as planets.

3rd. Masses incomparably smaller, as particles or molecules.

4th. The ultimate atoms.

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* The term *body* is here used in its most general sense, viz., as standing for a piece of matter in general, without regard to size. It may mean a planet or an atom; and it may even apply to such extra-material things as the æther and the hypothetical ultra-mundane corpuscles, or to anything else which is sufficiently like ordinary matter to be capable of possessing energy and of doing work therewith.

† It seems preferable to speak of the work as being done by the *body* rather than by *force;* though the latter expression is undoubtedly convenient sometimes.

‡ This step is rendered necessary by the preceding one of considering the work as done by the *body*. If it is the force which does the work, it is unnecessary.

§ Or power of doing work. But either term is objectionable, because *power* means *rate of doing work*. The term entropy has been used, but I believe that the accepted connotation of this word is now different.

|| This definition of energy, as the effect produced in a body by an act of work, is not so simple as the usual one—"the power of doing work;" but this latter definition seems a littly unhappy. For energy is power of doing work in precisely the same sense as capital is the power of buying goods. Now a sovereign has an infinite power of buying goods if at has any at all—twenty shillings worth being bought whenever it is transferred from one man to another. The proper statement is that a sovereign usually *confers upon the man that possesses it* a certain buying power, which power he loses when he has transferred it; and in this sense money is a power of buying goods. It does not, however, *necessarily* confer upon its owner any buying-power, because there may not be any accessible person to buy from; and if there be, he may have nothing to sell. Just so with energy: it usually, though not necessarily (see § 14), confers upon the body possessing it a certain power of doing work, which power it loses when it has transferred it. The analogy here indicated will be found useful in teaching.

Energy corresponds to capital.

Doing work corresponds to buying.

Doing anti-work corresponds to selling.

The transfer of capital is accompanied by two equal opposite acts, buying and selling: and it is impossible for one to go on without the other. Hence the algebraic sum of all the buying in the world is always zero: this is the law of the conservation of capital.

* And possibly strained as well. It is only forces which, like gravity, act uniformly on every particle of a body, that can move an ordinary elastic solid without straining it.

† Energy and work are not to be confounded together; and all such phrases as "accumulated work," "conservation of work," "conversion of heat into work," "work consumed," &c., should be eschewed. Energy is not work, but work can be got out of it if the proper condition be supplied. It is in fact *possible* work.

The expression *possible energy*, however, is meaningless; so also is the expression *actual* energy. All energy is *actual* and *real*—potential just as much as kinetic; and all represents possible *work*—that is, work that will become actual as soon as the other factor is supplied.

‡ The *cause* of the stress exerted by a strained body in any particular case is not in general known, and it may easily turn out often to be ultimately due to a kinetic phenomenon, as it certainly is in the case of the stress exerted by a compressed gas; nevertheless it may still be called static energy so long as the cause of the stress is not under consideration.

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All these material bodies agree in general properties, and differ only in size. But distinct apparently from these there exists an unknown *something*, which is material enough to be capable of possessing energy, to disturbances in which electrical phenomena seem to be due, and of which probably an aspect has been called æther. This must therefore constitute a 5th group, differing from the others apparently in respect of nature, not of size.

13. All these groups of bodies may be strained or set in motion in various ways when work is done upon them; and the groups into which the known forms of energy are thus thrown are exhibited provisionally in the following Table :—

Bodies.	Energy of Motion, or Kinetic Energy.		Energy alternately kinetic and potential.	Energy of stress, or potential energy.
	Rotation.	*Translation.*	*Vibration.*	*Strain, &c.*
Planetary masses ...	1. *E.g.* Earth's diurnal motion.	2. *E.g.* Earth's annual motion.	3. *E.g.* The moon's libration. Tides. Pendulums.	4. Energy of gravitation. *E.g.* A head of water. A raised weight.
Ordinary masses ...	5. *E.g.* Fly-wheel.	6. *E.g.* Cannon-ball. Rivers.	7. Sound-vibrations. *E.g.* Tuning-fork.	8. Energy of strained elastic bodies. *E.g.* Watch-springs.
Particles or molecules	9. Part of the heat-energy of fluids.	10. Most of the heat-energy of gases.	11. Heat-energy of solids.	12. Energy of molecular stresses. *E.g.* "Internal work."
Atoms	13. Unknown motions which take place during the act of chemical combination and during dissociation.	14. The translation of atoms is observed in electrolysis.	15. The period of atomic vibration is observed by the spectroscope.	16. Energy of chemical affinity.
Something..	17. Magnetism.	18. Electric currents.	19. (1) Discharge of accumulators. (2) Radiation.	20. (1) Electrostatic stress. (2) Electro-magnetic stress.

[The numbers in the compartments are merely for convenience of reference.]

It is quite possible that the form of energy indicated in compartment No. 4 would be better placed in No. 8, those now in No. 8 being placed in No. 12; but I have placed them as they now stand because they are closely connected with the vibration-forms in the same rows. Moreover the true position of gravitation energy cannot be properly defined till we know more about it. It may have to come under the kinetic head—the motion of Le Sage's corpuscles.

Probably the arrangement of the forms in the last row may be improved, but I am not sufficiently acquainted with the Maxwellian theory to do it. Neither do I know whether one is justified in pointing out an analogy between the two forms of strain indicated in No. 20 and simple and torsional shear,—or whether one may imagine that the volume-elasticity and Young's modulus of the "something" are infinite, but that its rigidity is finite though high. An apparently consistent, though rather hazy mental image of some obscure phenomena, may be built up on a basis like this; but it is too speculative to be mentioned further here.

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14. The power of doing work conferred upon a body by the possession of energy does not depend upon the absolute quantity of that energy only, but on its transferability. If it is not transferable, the body possessing it has no power of doing work.

15. Energy which can be guided, and all, or nearly all, transferred to any body at pleasure, is called a high or available form of energy, and is said to be capable of doing "useful" work, this work being done every time it is transferred in desired directions.

Energy which is nearly incapable of being guided, and which transfers itself in directions not required, is called a low or unavailable form of energy; and the work done at each of its undesired transfers is called "useless" work*.

16. The distinction between high and low forms of energy is a relative one, and depends on our present power of dealing with matter.

Masses of matter comparable to our own bodies in size can be handled and dealt with singly; and so they can in general be caused to do work upon, and therefore transfer their energy at pleasure to, any of the numerous accessible bodies which are competent to receive it. Hence energy possessed by them is generally of a high form.

17. Planetary masses can be dealt with singly indeed, but so singly that there is scarcely† any other body accessible to which their motion can be transferred‡ (see § § 4 and 14).

18. The energy of moving molecules is not very available to us, because we can only deal with them statistically and not individually. There is a large amount of relative motion and transferrence of energy constantly going on among individual molecules; but, as we have no control over it, the work done is useless, and the energy unavailable. The only part of the energy which can be transferred at will to external bodies is that due to the *average* state of the moving molecules; and it is not possible to transfer even this unless some other mass is accessible, the average state of whose molecules in respect of motion or strain is in some way different, so that the one is able to do work upon the other.§

Now, since all accessible bodies have very large stores of molecular energy, it follows that a very great portion of the energy which belongs to the molecules of a body must be totally unavailable to us, because it can never be got rid of or transferred. And even the portion which can be transferred at pleasure to some larger body, if not made use of quickly, will be found to transfer itself to neighbouring molecules and in directions not required, and will waste itself in doing useless work. Hence molecular energy is called a low form.

19. Atomic or chemical energy seems at present to rank a little higher than molecular energy, for though one way of availing ourselves of it is by converting it into molecular energy (heat) and then doing useful work with the balance of the average effect by which the body heated excels its neighbours, yet animals and galvanic batteries are able to do useful work with it in a more direct and less wasteful fashion.

The unknown or electrical energy appears to rank distinctly above the energy of molecules, because we have found some remarkable and indirect means of transferring the energy of electric currents to ordinary masses by the intervention of electro-magnetism with a comparatively small waste.

20. When energy passes from a higher to a lower form it is said to be *degraded*, and when it has no availability at all it is called *dissipated*.||

Energy is degraded when it is transferred from masses of ordinary size to the molecules of which they or others consist (§ 18).

The two fundamental forms of energy are those due to motion and those due to strain (§ 9). Now, whenever motion takes place against friction some energy is always transferred to the molecules of the rubbing surfaces; and whenever strain is produced in imperfectly elastic bodies some energy always passes to the molecules.

But in practice no motion takes place without friction, and all bodies are imperfectly elastic. Hence energy is continually getting dissipated; or, in other words, at every transfer of energy between ordinary bodies under ordinary circumstances,

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* The distinction between useful and useless work is quite accidental, and belongs more to economics than to physics. An engineer will often degrade the whole of a large quantity of energy in order to produce some superficial result which he happens to desire at the moment, *e. g.* when a planing-machine smooths a surface; or when a locomotive transfers passengers or goods between places on the same level.

† The well-known exception is the ocean, which by the agency of the moon is put into a slightly different state of motion from the rest of the earth; and a minute portion of the earth's energy of rotation is constantly being transferred to it. A portion of this tidal energy is now available to us, and may be made to do useful work.

‡ Hence the kinetic energy of the earth is of no more use to us than a bank-note to Robinson Crusoe.

§ An analogy may be drawn between the molecular energy of a body and the money of a bank, of which a reserve fund is kept for internal transfer and transactions between customers, while the excess gets invested in external concerns which have a deficiency, and so becomes available for doing useful work. To make the analogy more complete, the clerks should be uniformly dishonest, or the coffers insecure, so that stored money should dribble away.

|| It is then of no more use to us than is our money to the inhabitants of Mars, who have no means of getting at it. Its terrestrial transferrences are to them useless.

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some of it is always and necessarily degraded into a lower and less available form.*

It may be useful to append the following summary of the contents of the sections:—1. Newton's third law. 2. Definition of work, + and —. 3. Denial of "action at a distance." 4. Definition of working-power. 5. Definition of energy. 6. Conservation of energy, and first law of thermodynamics. 7. Possibility of various forms of energy. 8. Classification of the forms of energy. 9. The fundamental forms of energy. 10. Kinetic and potential energy are related to the two factors in the product work. 11. Transformation from one form to the other. 12. Further subdivison of the forms of energy. 13. Classification table.

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14. Distinction between energy and what was once called entropy. 15. Distinction between available and unavailable energy, and between useful and useless work. 16. Reason why the energy of ordinary masses is available. 17. Reason why planetary energy is almost unavailable. 18. Reasons why molecular energy is much of it unavailable, and second law of thermodynamics. 19. Extent of availability of atomic and of electrical energy. 20. Dissipation of energy.

* For instance, during every quarter-swing of a free pendulum, energy is being transformed from kinetic to potential, or *vice versâ*; and is being transferred from the unknown gravitation agent to the mass of the pendulum, or back again. Some, however, is dissipated every time, and ultimately the pendulum must stop.

CORRESPONDENCE.

(TRANSLATION.)

EDISON'S ELECTRIC GENERATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to offer a few observations in relation to the electric generator of Edison, a description of which, from the *Scientific American*, is given in your issue of Oct. 25. These observations relate to the question of the work transformed into electricity as a function of the external resistance of the circuit. Mr. Edison's machine, considered from this point of view, is simply a magneto-electric machine; since the exciter is not inserted in the circuit of the coil.

Such a machine, with a given velocity, gives a constant electromotive force, as is proved by the experiments of MM. Mascart, Hopkinson, Robert Gray, &c. Under these conditions, the work transformed in electricity is expressed by the very simple formula,

$$W = 10 \frac{E^2}{R} \text{ meg-ergs},$$

deduced from the laws of Ohm and Joule. Here W is the work transformed into electricity, E the electromotive force in volts, and R the total resistance of the circuit in ohms.

From this it follows that, in Edison's machine *the work transformed into electricity is inversely proportionate to the total resistance of the circuit.* It is true that in the Gramme and Siemens' machines, when the resistance is augmented, the work transformed into electricity decreases more rapidly than in machines with separate inductor. But if we take into account the work expended in exciting this inductor, and the complication introduced by the use of the second machine, it is easy to see why M. Gramme abandoned an arrangement which Mr. Edison more or less happily rejuvenates.

The machine of Mr. Edison being based on *no new principle*, is subject to the law commonly applicable to magneto-electric machines, whatever may say the too enthusiastic reporter of the *Scientific American*.

If the subject required to be treated in a more complete manner, I could furnish you with experimental results very conclusive on the above points.—I am, &c., E. HOSPITALIER.

24, Rue Freycinet, Paris.

The following letter has been addressed to the editor of the *Scientific American* by Mr. Edward Weston, of Newark, N.J.:—

"I can scarcely conceive it as possible that the article on the above subject in last week's *Scientific American* could have been written from statements derived from Mr. Edison himself, inasmuch as so many of the advantages claimed for the machine described and statements of the results obtained are so manifestly absurd as to indicate on the part of both writer and prompter a positive want of knowledge of the electric circuit and the principles governing the construction and operation of electric machines.

"It is not my intention to criticise the design or construction of the machine (not because they are not open to criticism), as I am now, and have been for many years, engaged in the manufacture of electric machines, but rather to call attention to the impossibility of obtaining the described results without destroying the doctrine of the conservation and correlation of forces.

"What the 'important fact' 'developed in the course of Mr. Edison's experiments with his generator' is (if it means anything more than what Hjorth, Wilde, Siemens, and Wheatstone set forth many years ago) I am unable to comprehend from the description given.

"It is stated that 'the internal resistance of the armature' of this machine 'is only ½ ohm.' On this fact, and the disproportion between this resistance and that of the external circuit, the theory of the alleged efficiency of the machine is stated to be based, for we are informed that 'while this generator in general principle is the same as in the best well known forms, still there is an all important difference, which is that it will convert and deliver for useful work nearly double the number of foot pounds that any other machine will under like conditions.' The explanation of this remarkable efficiency I quote: 'Now the energy converted is distributed over the whole resistance, hence if the resistance of the machine be represented by 1, and the exterior circuit by 9, then of the total energy converted nine-tenths will be useful, as it is outside of the machine, and one-tenth is lost in the resistance of the machine.'

"How any one acquainted with the laws of the electric circuit can make such statements is what I cannot understand. The statement last quoted is mathematically absurd.* It implies either that the machine is *capable of increasing its own electromotive force nine times without an increased expenditure of power*, or that external resistance is *not* resistance to the current induced in the Edison machine.

"Does Mr. Edison, or any one for him, mean to say that $\frac{r}{n}$ enables him to obtain nE, and that C is *not* $= \frac{E}{\frac{r}{n} + R}$? If so, Mr. Edison has discovered something *more* than perpetual motion, and Mr. Keely had better retire from the field.

"Further on the writer gives us another example of this mode of reasoning, when, emboldened and satisfied with the absurd theory above exposed, he endeavours to prove the cause of the inefficiency of the Siemens and other machines. Could'nt the writer of the article see that since $C = \frac{E}{r + R}$, that by $\frac{R}{n}$ or by making $R = r$, the machine would, according to his theory, have returned more useful current to the circuit than could be due to the power employed (and in the ratio indicated), so that there would actually be a creation of force!

"If such statements as these have been made by Mr. Edison to the representatives of the daily papers, I think he has no cause to complain of the treatment received, but rather to consider himself fortunate that he has escaped rougher handling.

"In conclusion, allow me to say that if Mr. Edison thinks he has accomplished so much by the *reduction of the internal resistance* of his machine, that he has much more to do in this direction before his machine will equal in *this respect* others already in the market. "EDWARD WESTON.

"Newark, N.J., October 13, 1879."

* The writer appears to confound the questions of *economy* and *efficiency*. *Supposing* E to remain constant, the current would be augmented five times by reducing the external resistance from 9 to 1; but five times the quantity of work would then be absorbed. Only half this work, represented by 2·5, would appear in the external portion of the circuit. But under the original conditions, though the work absorbed, on the above assumption, would be five times less, it is not "absurd" to say that nine-tenths of it would be useful work. As a matter of fact, E does *not* remain constant.—ED. *E.*

THE JABLOCHKOFF BOUGIE.—The *Correspondance Scientifique* points out that this electric candle has been both improved and cheapened. Formerly it burned only for an hour and a half; it now lasts about two hours. For an establishment like that of the Louvre, which burns about 80,000 bougies a year, this alone means an annual saving of about 10,000fr. But the bougie, which was first sold for 7½d., was afterwards reduced to 6d., and has now fallen to 5d.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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THE SOCIETY OF TELEGRAPH ENGINEERS.

The Society of Telegraph Engineers will resume its meetings for the Winter Session in the course of a few days. The recess has been a somewhat eventful one, and the prospects of the Society will depend very much upon the outcome of what has already been done, and what it has determined to do in the immediate future. As a Journal we are peculiarly, we might say necessarily, interested in the welfare of this important public Institution, and we feel it therefore to be, not merely our duty, but our right to watch its proceedings carefully, and to criticise them freely when occasion seems to call for criticism.

As regards the past we are glad to be able to say that the Society has reason to be proud of the reception it gave to the Delegates of the International Telegraph Conference. True, it fell short of what we had sketched out for it; but it might have fallen still shorter had we not aimed higher than the practical probabilities seemed to warrant. What it might have been if, on the one hand, the Society had had Government funds to draw upon; or, on the other, had the Government had the telegraph profession entirely at its disposal, is now a question not worth discussing. As it was, the tax and strain upon the resources of the Society were very great; and what it achieved not only reflects much credit upon itself, but, to our thinking, has imposed a debt of gratitude upon the Government Telegraph Administration of this country which ought not to be soon forgotten.

With regard to the Cape cable project, although opinions may differ as to the part played by the Society in the selection of the route, it will be a subject of congratulation to all alike that this, probably the most important national telegraphic undertaking of modern times, has been so far successfully accomplished. The good fortune which has uniformly attended the parties who have charge of this cable augurs well for its stability when completed.

We have noticed the papers appearing in the Society's Journal, two numbers of which have appeared during the recess. We refer to them now only to make one or two general comments. Firstly it is noticeable that a longer time than formerly elapses between the meetings and the publication of their proceedings. Greater care is bestowed upon the diagrams which now profusely illustrate the Journal; but we cannot help thinking that something is lost in making it a mere dry record of what is past and gone. There are times when the prompt issue of an interesting paper would be not only of immediate use to distant members; but would help to give life to the debates which are to follow. The question of expense of course has to be considered; but in one particular at least the present outlay might be diminished. It surely cannot be necessary to report desultory conversations, votes of thanks, and the like, verbatim. At all events, if the reporter finds it necessary—because it is so much easier—to report these matters rather than the gist of a valuable scientific speech, there is certainly no need to *print* them. The ordinary reporter, as we know by hard experience, although highly ornamental, is practically useless—industriously taking down all the padding, but driven to the ceiling in despair when the bone and muscle claims his attention. In short, we think that the Journal would bear a good deal of excision, and that, except on rare occasions, the notes of the editing committee would be of more service, as well as briefer and cheaper than those of a shorthand writer.

Dealing now with the future of the Society, we come to a question which provoked some sharp comments at the last general meeting. That meeting was painfully thin in its attendance. The council was largely represented at the table, and the members by empty benches in front. The cause in this particular instance was probably the quite exceptional course which had been adopted in nominating for election only just the number of persons required to fill the vacant places on the council. There was of course no interest felt in the foregone result of a mere formality of this kind. Attention having been called to the incident it is not likely to occur again; but in this connection we cannot help pointing to the desirability of giving the members a more active share in the working of the society. It is manifestly good policy to do so; and, exercised with judgment, a great show of concession might be made without jeopardising in any way the welfare of the Society or interfering with the final authority of the council. There has never up to the present time been the least symptom of hostility on the part of the general body of members; but hostility would be preferable to indifference; and one or the other of these sentiments is pretty sure to develop itself if a suspicion arise that members have no choice in the elections and no consulting voice in the management.

And there is one subject which we think might well be referred to the members just now, if the council has not already made up its mind upon it. We refer to formation of an Electrical Society. We dealt with this matter at some length about eight months ago (*The Electrician*, March 22, 1879); and ample opportunity has been given for its consideration in the interval. For reasons which will be sufficiently obvious, we did not publish the letters we received relating to our proposition. They differed in their views as to the mode of carrying it out: but they one and all confirmed us in the estimate we had formed of the crying need there was for the thing itself—namely a society for the examination and promotion of electrical science, as such, in addition to, though not necessarily apart from, its practical application to the purposes of Telegraph Engineering. If

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any objection was taken to it at all it was mainly on grounds of practical expediency. This was the exception however; and in our main contention we received powerful and unexpected support from one of the foremost members of the Telegraph Engineering profession. The letter which Mr. Latimer Clark addressed to the President and Council of the Society, and which we published in our issue of May 10th, appears to have been suggested by our leading article—for it bears the same date—and it puts the case very strongly; indeed argues in favour of it chiefly on the grounds of its urgent expediency. He says:—

"At the time of the formation of our society, and on subsequent occasions, I have endeavoured to point out the danger and disadvantages that would arise if our society were to assume too professional and technical a character, and to fail to attract the support of that large and increasing body of electricians who have no connection with telegraphic engineering or the practical applications of electricity, but who pursue the subject from a pure love of science."

Mr. Clark states that many workers of the highest acquirements are not members of the existing society, bearing as it does a title that is distinctly professional and technical. He then makes this significant remark:

"It appears to me quite possible that the class of whom I am speaking may, before long, become sufficiently numerous and powerful to support an independent society *unless we ourselves occupy the ground thus left vacant.*"

Here therefore we have the testimony of one eminent authority that the demand for an Electrical Society is pressing, and that it may be powerful enough to create an independent organization if no countenance is lent to it by professional Telegraph Engineers. Mr. Clark is naturally anxious that the society to which he appeals should of its own motion cover the ground and leave no room for the formation of a quite new society. We are not disposed to advocate any one scheme in preference to another; we desire only to see the want supplied in an efficient manner. Clearly it behoves the Society of Telegraph Engineers to attract that class of Electricians to whom Mr. Clark refers; and no professional jealousies ought to stand in the way of the endeavour to do so. The formation of an independent society would probably be the signal for a serious secession from the older society. But that, after all, is its own affair; and if it neglect the warning it must abide the consequences. A very good case could be made out for a specific Electrical Society; and it has so little to gain from association with Telegraph Engineers that it is not likely to go begging for affiliation if once it comes to life unassisted. On the other hand, the Society now in possession would have much to gain by enlarging the scope of its functions. It is idle to say that the proceedings of the Society may and do cover all that is practically needful. The Geographical Society might object with almost as much reason to the separate study of Geology. The Telegraph is only one application of Electricity among several, and every year adds to the number of these applications. Strictly speaking, the Electric Light has no business at a meeting of Telegraph Engineers; Dynamo-machines have never been discussed there at all, nor has the application of electricity to any of the Industrial Arts. Here are fields of operations even for men who pride themselves on being exclusively practical. A "Society of Electricians" would embrace all this and would besides attract persons who pursue the study of Electricity "from a pure love ot science." On these grounds we think Mr. Clark is right in suggesting a new title for the Society that gives prominence to the Electr cal s de of it.

This, however, is a matter of detail which may properly be left to the discretion of the Council of the Society of Telegraph Engineers. On some points they would be wise to take the opinion of the members, very many of whom, as we have already hinted, are Electricians without being Telegraph Engineers; and their wishes ought to be considered. In any case we should strongly deprecate the abandonment of the subject altogether without reference to the general body of members.

CANTOR LECTURES.*

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece, Electrician to the General Post Office.

Lecture II.

(concluded from page 281.)

We could trace the vapour arising, as it were, in the South Wales district, somewhere in the neighbourhood of Bristol, and gradually proceeding on its way, as indicated by its influence upon our wires working from the central station, right across England towards the North. Fortunately, this extremely marked effect only occurs at rare intervals, but there are two periods in the day at which a similar effect is experienced, though in a much milder form. Immediately before sunrise there is always a deposition of dew on our insulators, when our lines test very badly, and we have a recurrence of the effect immediately after sunset. These two periods are marked unmistakably by the action on our wires. You see, in this particular branch of insulation, experience again has led us to various improvements, so that, compared with the goose-quill in the days of old, the insulator of the present day stands almost pre-eminent.

As regards the supports of these wires and insulators, experience has pointed out that, on lines of a small number, such as one or two wires, 16 poles to the mile are sufficient. On main lines carrying a number of wires, it is necessary sometimes to have as many as 24 poles per mile. In the early days the most expensive timber was used for these poles. The very best Memel timber that could be procured was utilised, and every pole cost a very large sum of money; but with experience wiser counsels prevailed, the expensive timber was found to be unnecessary, the common larch timber of this country was used, and continued to be used for many years. But it was found that plain timber, in this very moist climate of ours, very rapidly decayed. It invariably decays at what is called the "wind and water mark"—that is, the ground line where the timber comes in contact with the earth. There is an alternate succession of moisture, heat, and cold at this point, and the result is the germination of vegetable and mineral growth, and gradual decay of the timber. To cure this, various processes were produced to try and preserve the timber. "Burnetising" consisted in saturating the timber with chloride of zinc; "kyanising" consisted in impregnating the timber with corrosive sublimate. In the "boucherising" process (taking its name, like the others, from the inventor) the pores of the wood were filled with sulphate of copper; and various other modes were applied, all of which proved inefficient except one. The successful process of preservation is that of "creosoting." This process is adopted with every pole in the Postal Telegraph service, and, I believe, with all poles on most of the railways. Creosote is antiseptic. It is something that will instantly kill any animal or vegetable germs in the timber, and it fills the pores of the wood with a waterproof material that keeps it practically dry. In fact, poles which were erected in 1848 on the Portsmouth line are now as sound as the day when they were first put in, and if a pole be properly served with this creosote, it will, as far as we know at present, last for ever. On the other hand, of course, the proper application of this antiseptic process cannot always be relied on, and poles have decayed from its imperfect application.

There are countries where wood cannot well be obtained, so that these preserving qualities are inapplicable, and where iron is used. In some countries iron is used to a very large extent. Through the kindness of Messrs. Latimer Clark, Muirhead, and Co., I have here a complete iron pole, many thousands of which have been sent to South Africa, South America, and various of our colonies. It is a very light and pretty pole. It has a cast iron base and a wrought iron cone at the top, and you can see how the insulators are fixed on brackets attached to it. On our wooden poles the insulators are fixed by means of wooden arms.

* From the *Journal of the Society of Arts* for October, 1879.

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Messrs. Siemens, whose name is a household word among telegraph engineers, have also some very light and elegant iron poles, not at all unlike the one on my left, but which are, perhaps, used at the present moment more than any other kind. Mr. Norman, of the firm of Tyers and Norman, has introduced on the Furness Railway a specimen of iron pole made of what is known as angle iron, and which is said to be very effective. But, comparing an iron pole with a wooden one, it is found that a creosoted Norway pine pole is cheaper, more efficient, and more durable, I believe, even than iron. I do not, personally, believe much in iron for telegraphic poles.

Now, there are many practices applied to poles which are useful and beneficial. For instance, suppose two wires were affixed to the two insulators, one at either end of the arm at the top of this pole, and that wet weather set in, and coated each insulator and soaked the arm with moisture. Water being a conductor, this moisture would allow of the current on the one wire to pass down the bolt to the arm, where it could either go down the pole to the earth, or pass along the other half of the arm to the other wire, and produce on that wire what is called a "weather contact." In the early days it was quite impossible to work one wire without producing upon a neighbouring wire, in wet weather, this "weather contact." To remedy this, a very simple process was introduced, which was to put all the bolts of the arms directly in contact with the earth, by means of a wire carried down the pole, and so forming a passage by means of which the current escaping from one wire went direct to earth without interfering with another wire at all. This process was found out by pure accident. In the early days, it was thought necessary to fit every pole with lightning protectors, to prevent their being shattered by lightning. Lightning does play havoc with our poles sometimes, but not to a very large extent; and it was found that, where the poles had been provided with these lightning protectors, the "weather contact" did not appear. Here is a sample of the very earliest kinds of arms used. You will see that they are fixed crosswise, or in the shape of a letter X, with a bolt through the cross, which bolt was connected with the earth by a wire, to prevent weather contact. These arms were erected about 1850, by the British Telegraph Company. You will notice that the insulators, which were white porcelain when put up, cannot be said to have retained their colour. They have become coated with a soot-coloured dirt, which has eaten into the porcelain, and cannot be rubbed off.

Now, having erected the wires upon the poles, we must have some simple way of "leading," or bringing them into the offices. We have a specially strong insulator at the terminal pole, to which the line wire is connected, and it is from this insulator that the gutta-percha covered leading in copper wire is attached to the line wire, and passed through the insulator into the pole, whence it is carried into the ground, and so on into the office. The insulator contains an inner cup, filled with oil, which prevents the current escaping. This form of insulator for leading-in purposes (of which a specimen is on the table) is of recent introduction, is now under trial, and there is every probability of its proving valuable. The old plan of leading-in was simply to attach the end of the gutta percha covered copper wire to the iron line wire, and to carry it direct to the pole, leaving the gutta percha exposed to the air, causing it to speedily crack and become defective.

Among the accidents to which open telegraph lines are liable, we must enumerate snow storms. Snow storms appear periodically. When I say snow storms, I speak of telegraphic snow storms. Snow storms we have frequently; but telegraphic snow storms, I am happy to say, are very rare. The telegraphic snow storm is always accompanied by frost and wind. The snow falls, and as it touches the wire it freezes, and adheres to it, forming a layer; another layer falls, and is frozen upon the first, and this process goes on till the wire becomes, say, as thick as my arm; and when this happens, and is succeeded by a gale of wind, the surface exposed to the wind is so great, that it is impossible for the strain to be borne, and it is simply a question of which shall give way first, the pole or the wire; one must go, and the result is that the wire, as a rule, gives way. It fortunately happens that, during the 40 years that telegraphs have existed in this country, there have been only two snow storms of this description. The one took place in the year 1866, and the other in 1877. Again, it is fortunate that, when these storms occur, they are confined to a small section of the country, and so the damage suffered from them is limited, as regards the area of the storm, but within that area the havoc done is very serious. For instance, the storm of 1877 swept the country in a broad band, from the Bristol Channel to the Wash; and along that broad band, of about 30 or 40 miles, everything was swept away as though the destroying angel had passed over the country smiting everything down. This has only happened twice, but, nevertheless, it may occur again, and to avert the damage, it has been considered, at times, whether we ought not to put some of our wires underground. There has been a great cry, particularly in the public papers, about this method of erecting our wires, and suggestions made that they should go underground.

We have a great many wires in this country that go underground. The telegraphs in this country consist of—

Miles			Miles			
11,055	of poles	and	30,921	of wire	upon	roads,
12,952	,,	,,	58,127	,,	,,	railways,
432	,,	,,	4,123	,,	,,	canals,
445¾	,,	line	9,023	,,	,,	underground,

making a total of 24,885 miles of line, and 102,194 miles of wire in the country.

The figures have not been brought up to date, and it may, perhaps, be roughly taken that there are nearly 10,000 miles of wire underground. But to put wires underground is a very costly operation. It costs a great deal more to put them under than over ground; but besides this there is another very great objection to underground lines of any great length, and that is that when you put wires underground you retard the rate at which they work, and diminish the capacity of the wire for the transaction of business, and so reduce its commercial value. Suppose, for instance, we were to erect an underground line from London to Liverpool. It would cost, perhaps, four or five times as much as an open line, but it would, in addition to that, diminish the capacity of the wires laid down in the same ratio. Such a line would not be able to transact, perhaps, one-fourth of the business that an overground line between the same points would carry. So that, assuming the underground line to cost four times an overground line, while at the same time having only one-fourth its carrying capacity, the commercial value of the underground would be one-eighth of that of the overground line.

In England we confine our underground lines chiefly to the neighbourhood of towns. In going through towns with a telegraph line we have the choice of carrying the wires overhouse, or of placing them in pipes through the streets. We prefer the latter, because the lengths of underground being short their retarding effect upon the wires is only felt to a very small extent, and it is owing to this fact that the overhead lines in London, which previously disfigured the town, are fast disappearing, and will, before long, have almost entirely disappeared.

When we come to underground lines, we depart from the use of iron wire for our conductor, and use copper wire. There the causes which render copper wire inefficient for open air lines cease, and we introduce copper, coated either with india rubber or gutta percha. Here, perhaps, as great an improvement has been made as has been made in iron, perhaps greater. When the Atlantic cable of 1858 was made, it struck Sir William Thomson that the results were worse than he expected, and he was led to examine the quality of the copper, and he found that it only gave 40 per cent. of the necessary standard. This caused the quality of the copper used for submarine and underground telegraphs to be carefully examined, and, step by step, has brought about the result that, when the Persian Gulf cable was made in about 1860, it was specified that the core should be made of 76 per cent. of pure copper. The quality really supplied was 89 per cent., which proved that the manufacturers had been fully alive to the necessity, and had surmounted the difficulty.

The specifications of the Post Office provide that the copper shall contain 94 per cent. of pure copper, and it very often happens that 98 per cent. is given. So that, since the Atlantic cable was laid in 1858, it is easy to see how very great an improvement has been made in the quality of the copper conductor used, greater, in fact, than the improvement which I mentioned as having taken place in the iron wire.

Copper wire, like the iron, is used of various forms and in various stages. It is generally covered with gutta percha. Gutta percha is the gum of a tree that is found in Borneo and the islands of the Archipelago, and it comes to this country in the crude condition of this mass which is before you. The copper wire is drawn through this gutta percha, when in a plastic state, and is then passed through dies, which regulate the size and shape of the covering, as you see.

The specimen before you is of the kind which is used generally for our underground lines. The weight of the copper is, I think, about 39lbs. per statute mile, and that of the gutta percha about 46lbs. per statute mile.

Where we come to the use of this wire for cables, various other preparations are used, and the speed at which a cable can be worked really depends upon the thickness of the copper, and the thickness of the gutta percha.

Curiously enough, gutta percha owes its introduction to a lecture delivered in this very room.

In 1845, a Dr. Montgomery exhibited a specimen of this crude stuff, which he had brought from Calcutta, where it had been

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imported and used for various purposes. It so happened that among the audience sat Dr. Siemens, who thought that there was something in this gutta percha. He obtained some of it, sent it over to his brother in Germany, Werner Siemens, in 1846, and, after some experiments, they found that it was a splendid insulator. It was applied as a coating to wires, and, in 1848, a great many miles of wire so coated were made and laid down in Germany. Germany is, in fact, the birthplace of gutta percha covered lines, and the first idea of the use of this article for such purposes was obtained from a lecture delivered in this room.

In 1851, the Electric Telegraph Company constructed a main trunk line of gutta percha covered wire from London to Liverpool and Manchester, consisting of eight wires, laid in pipes buried about 2ft. in the ground. In those days, the method of making joints was unknown (really, one blushes now to think of the many mistakes that were made), and the result was that this underground line proved a desperate failure. It lasted only three or four years, was taken up, and from that day to this we have not done very much in this direction, for the reasons I have stated. But between Liverpool and Manchester, an underground line has been constructed with all our present experience, and with the knowledge of the failures made in the past, and it has proved, up to the present time, to have been very successful. But, notwithstanding this, as I told you, I do not think it is at all likely that we shall extend operations in this direction very much.

I have, on the table, specimens of underground work laid in Germany. In England it is our practice to draw these wires into earthenware or iron pipes, but in Germany they have taken their idea from a submarine cable (to which I shall refer presently), and there they take seven gutta percha wires, form them into a strand, or rope, protect that rope with iron wires outside, and cover the whole with a bituminous compound, and lay it, just as it is, in the ground. Where rivers are crossed, exactly the same cable is used, but a thicker outside coating of iron wires is used to give it strength. There are many hundreds of miles of such cable now laid in Germany, and, in fact, all the principal towns there are connected by means of these cables, buried, I think, a little more than a mètre deep.

In England we adopt a different plan, and draw the wires into pipes, and in the streets of London we have pipes laid such as you see here. This is the principal kind we use. It is three inches in diameter, and will contain 70 or 80 wires. The section before you contains a number of wires which have been drawn in. The pipes are laid down, an iron wire is threaded through them, and as that iron wire is drawn out, so it draws in the gutta percha wires that are cabled up as you see there.

Gutta percha wires would be very well if they would last. But, unfortunately, gutta percha is a gum that only appears to last when in water. In water it apparently is indestructible. Cables that were laid in 1851, that have been brought up within a recent date, are now as good as the day when first put down. But when gutta percha becomes exposed to the air, to the alterations that our climate and other climates suffer, especially when exposed to the action of the sun it decays very rapidly; it oxidises, and becomes a kind of resin that can be easily crumbled into a snuff-like substance. Many attempts have been made to protect the percha, and to arrest this rapid decay. It has been surrounded by tape soaked with tar. Tar itself has been found to be injurious, and has been supplanted by other materials, but at the present moment we have not yet succeeded in finding anything that renders gutta percha indestructible. In fact, when exposed to air, as when suspended in tunnels, it seems to have a life of about ten years; when laid down in our iron pipes under the influence of the variations of temperature and moisture that exist there, it seems to last about twenty years; but in the sea, where it is exposed to equable temperature and equal conditions, it apparently seems capable of lasting for ever.

There are many curious accidents and causes of interruption to working that we meet with in our gutta percha covered wires, and one of the strangest is one of the last that we have discovered. We have found in many places that this gutta percha is apparently gradually eaten away. It seems to go not unlike the way in which open air wires rust away; and this curious action only occurs in certain places. In certain parts of the country, North Wales, Dublin, Kent, and in one part and another, we have found this curious action going on; and careful examination and inspection under the microscope have led us unmistakably to conclude that it is due to something or other eating away the gutta percha. Curiously enough, wherever we have detected this action taking place there also we have found swarms of a very minute insect—a very little thing—belonging to what is called the spring tail tribe. It is a little white fellow that you can scarcely see, and who, by the way, when you do see him seems conscious of the fact, for he immediately disappears with a spring. It is the *Templetonia crystallina*. It abounds in swarms in certain soils, and seems to have a great liking for gutta percha. It does not remain near the wire when it has eaten its way through, but apparently immediately retires when it touches the wire, as though it had received a shock, and makes a sudden retreat. It is a very curious fact, and until recently it was unknown, that any living creature had a taste for gutta percha. There are a great many specimens of gutta percha on the table that have suffered from the attacks of this little insect, which, no doubt, you will look at with interest. There are also specimens of gutta percha wires that have been mauled by rats, who, from their mischievous habits, often cause us great trouble. We have had gutta percha wires damaged by field-mice, and even by rabbits. I had a specimen, damaged by mice, which, most unfortunately, got lost in the post. There were absolute indications of their little teeth on the copper wire itself.

Again, there is a fungus which damages gutta percha; this generally happens in the neighbourhood of oak trees. But we have got another animal called man that sometimes also disturbs gutta percha, and in Hull, not very long ago, all our wires on one particular route were broken down, and it was found that a man, in laying down a drain, had deliberately cut the wires, and when he was remonstrated with he said "but I put them back again." He made two great cuts through the percha and put the wires back again, leaving it very difficult for us to find the place.

Sometimes through towns our wires are carried overhead. In that case the wires are frequently made up into cables, and india rubber is then used for the purpose. Here are some blocks of crude india rubber, showing the way it is imported into this country. There are several blocks of different qualities, but the best quality we obtain from Para. Here is a wire that has been coated with india rubber, intended principally for torpedo cables. Where india rubber is used for overhead purposes, the wires coated with it are made up into cables according to the specimens before you, of various numbers, ranging to as many as 50 in one cable. The wires are very finely covered with a thin coating of india rubber, and when cabled up are suspended from pole to pole overhead along the streets. Such cables are used very largely for private wire purposes, in working an instrument which I shall have the pleasure of showing you next meeting, I mean the Wheatstone A B C instrument. But it is when we come to consider submarine cables that gutta percha and india rubber become of immense consequence. There a cable has not only to pass a deep and long sea, but it has to brave various contingencies, and besides being requisite that it should be of proper capacity to carry currents for its distance through the water, it should also have strength to enable it to fall to the bottom of the sea, and also have sufficient strength to permit of it being hauled up again in case of failure, and in case of repairs being required.

Submarine cables are really practically of only one type. The first cable was that laid down in 1851. A cable, in the principles of its construction, is nearly the same everywhere. You, first of all, have copper wire, which is your conductor, and which conveys the currents which operate your instruments. This copper wire is surrounded by a coating of gutta percha, such as you see. It is then coated with a layer of hemp well saturated with tar, sometimes with tar water, and then, to give it strength, the whole is surrounded by a strand of stout iron wires. So that there you have conductor, insulator, serving, and outside wires, and all cables really follow this type. Here, for instance, is a river cable, strong and heavy, intended for a river where ships drag their anchors, and where strength is of consequence. In the glass case on the table you will find specimens of all the different forms of Atlantic cables, and the collection is well worth your examination. There is a specimen of the Atlantic cable of 1865 and of 1866, with their shore ends. There is a piece of the 1865 cable which was brought up from a depth of 2,000 fathoms.

There is a piece also of the grappling rope itself which brought that cable up, and you will also find in the case a model of the grapnels used to bring the first Atlantic cable up to the surface in 1866.

Here are specimens of the cable which is about to be laid down from Aden to the Cape of Good Hope. There are three specimens, one being that of the portion used for the deep-sea section, the second of the first shore-end section, and the third being provided with a still stronger outside covering for the shore-end proper. The deep-sea portion is much thinner than either of the other portions, but it is sufficiently strong to bear five or six times its own weight in water. It has sufficient specific gravity to descend with the requisite velocity to the bottom, and, when there, it has all the properties requisite to make it durable for a great many years. But no cable has yet been immersed, or even devised, which can be said to be perfectly durable. The form of the Atlantic cable of 1865 and 1866, which is similar to that of many other cables, was deficient, inasmuch as, while it possessed

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sufficient strength to enable it to be submerged, it had not sufficient durability to retain that strength to enable it to be brought to the surface again. And when the cable failed, the repairing ships sent out were utterly unable to bring it to the surface in a sufficient length to enable them to effect repairs.

Here are also some interesting specimens of the direct United States cable. The cables of 1865 were made by the Telegraph Construction and Maintenance Company, but the direct United States cable was made by Messrs. Siemens. The difference between the two is very slight indeed. There is a little difference in the form of conductor, but the principle of the two will be found identical.

The deep sea portion of the Cape cable, while it differs to a certain extent from the Atlantic types, is still deficient in that absolute durability which all cables ought to have; in fact, there is room for invention in this direction. Generally, one notices that where there is a want some one will spring up with an invention to meet that want. Here is a want that has existed for many years, but no one has invented a cable which can be said to be perfectly adapted for its purpose; so that, if any one here is of an inventive turn, let me recommend him to try his hand at inventing a cable which will give us all the requirements needed.

This cable to the Cape has one peculiarity in which it differs from any others. Now among the various accidents to which cables are subject there is one due to the existence of life at the bottom of the sea. We know that in different seas there are certain little insects—sometimes *Teredos*, sometimes *Xylophaga*, sometimes *Limnoria*, and others of very hard names—which have a peculiar liking for gutta percha. These little *Teredos* attack us on sea as well as on land, and the trouble they cause us is sometimes immense. We suffer from them very much on the Irish coast, where the little wretches have found their way to the gutta percha, and have there scored and figured it in a very curious way, samples of which you will see on the table.

To put a check to their boring instinct, the Telegraph Construction and Maintenance Company, who made the cable which is being laid to the Cape, but which was originally intended for Australia, have surrounded the gutta percha with a wrapping of brass; and if any of these boring insects abound in any portion of the line where this brass wrapping is used, I have no doubt that the brass will be too much for them, and that they will find themselves terribly beaten in making any attempts to get at the gutta percha.

It is found that these little animals do not exist at greater depths than 100 fathoms, and, therefore, in the deep sea portion of this cable, the brass wrapping will not be found.

There are a great many accidents to which submarine cables are subject. One of the principal is that of a ship's anchor, and it was the disturbing element of a ship's anchor that prevented me from having the pleasure of being before you last Monday. On the table is a piece of cable which has been taken out of that crossing the river Humber. The cable which crosses this river is one of the most important that we possess, and for that reason one of the strongest kind of cable ever made was laid down. In the Postal Telegraph Department we have no less than 62 cables, and their aggregate length of 1,224 miles contains a total of 3,809 miles of wire. To cross rapid streams and important rivers, strong cables are used, and to cross the Humber, which during spring tides runs at the rate of six to seven knots an hour, a cable of the strongest type was used; yet it had not been down six weeks when a ship got hold of it, and the cable was caught by its anchor. The heavily-laden schooner riding on a strong tide, with its anchor attached to the cable, brought to bear an enormous force, and, perhaps owing to the construction of the cable, this force would not be equally divided among the outside protecting wires, and thus one wire, bearing the greater strain, gave way, followed by the snapping of a second, and so on, till the whole cable was severed in the straggling and tangled manner that you see, which is very different from its symmetrical form when first laid. This break occurred in a very nasty stream, where the cable was so buried in mud that I could not find it, and I was despairing of being able to give even a second lecture here when a happy thought occurred to me. I had spent a whole day in grappling after this cable, trying over and over again, and yet never getting near it, when it suddenly came into my mind that Shakespeare makes Bassanio say, "In my school days, when I had lost one shaft, I shot his fellow of the selfsame flight the selfsame way, with more advised watch, to find the other forth; and, by adventuring both, I oft found both." So, knowing that a ship had dropped its anchor over the cable, I thought we would drop our anchor too; and we did, and waited a whole tide, and when we hauled the anchor up there was the cable.

The chief cause of accidents to cables, next to that of anchors, is probably due to the abrasion of cables on rocky bottoms. The bottom of the sea is frequently of an undulatory nature, and the cable remains suspended from point to point, and at such points the wire becomes chafed and worn away, and speedily decays. I am sorry to see that the time at my disposal has gone so rapidly, that I cannot particularise to you many of the different causes that lead to the destruction of cables, not only abrasions, not only accidents in paying out, but accidents that exist afterwards; for instance a whale once caught a cable in the Persian Gulf and broke it; a shark's tooth has been found embedded in a cable, and a sinking ship has caused damage to a cable.

Sometimes, the cables rest on corrosive stones, copper ores, and ironstone, when corrosion sets in, and causes the cable to speedily fail. Volcanic action sometimes damages cables, as also rock slips. In the Bay of Biscay, which is crossed by the Direct Spanish Company's cable, there is no doubt that such a cause has interfered with the cable on two occasions; curiously enough, interrupting the wire each time on the same day of the year. There is a peculiar shelving of the rock, and slips exactly equivalent to our landslips take place at intervals.

Icebergs, too, from the North Atlantic, frequently carry large pieces of rock, which fall to the bottom when the iceberg thaws, and in their descent, are liable to fall across a cable and damage it.

There are also faults due to imperfect joints, due to accidents that pass inspection during the process of manufacture, but which slowly develop themselves after submersion or lapse of time.

Lightning, earth currents, and things of that kind affect cables, but, nevertheless, the eye of the telegraph engineer is constantly watching these circumstances as they happen, and he tries to bring to bear upon them all the power and thought he possesses; and the result is that, by slow experience, the cable of the present day is very superior to that used in the early days, and the improvement has been equal to the advance, which I hope I have been able to show you, has been made as regards the insulators and iron wire.

THE TELEPHONE.—The following is the report of a Lancashire paper of a lecture, under the auspices of the educational department of the Oldham Industrial Co-operative Society, delivered last week in the Queen-street Sunday School, by Mr. Edmund Wheeler, F.R.A.S., of London. The chair was occupied by Mr. Thomas Wheeler, and there was a large attendance. The lecturer, in his introductory remarks, said the telephone was not the work of one man, but that many people had, at different times, made experiments with telephones. From 1860 downwards, several men had been engaged in experiments, and the perfection of all was Bell's articulate telephone. The three branches of science were sound, electricity, and magnetism combined with sound. Sounds were caused by motion. By striking the bell which he (the lecturer) had in his hand, it vibrated, and not the hammer. He further illustrated this by sounding a tune fork, and placing the end to a piece of board. The board then vibrated, and communicated with the air around. Air was sometimes called a conducting body. Liquids were good conductors, especially water, but a solid body was still better. The telephone was better than anything that had been made yet, because electricity was the agent. A whisper could be heard at a distance of 100 miles as well as 100 yards. Electricity was produced by the sun, the earth, and the growth of herbs, but it was also produced artificially, and used in the work of the telegraph. Iron and steel were not magnetic, but they might be made so. [Iron, steel, nickel and cobalt are considered by all the received authorties as magnetic bodies, by reason of their being inductively influenced and attracted by magnets. The statement as to electricity being *produced* by the sun and the earth is, to say the least, very indefinite.—ED. *E.*] Iron became magnetic very quickly by connecting it to a battery, but it lost this property in an instant when disconnected with the battery; whilst steel became magnetic slowly and permanently, and would retain it for thousands of years. As an experiment a wire was connected with the telephone, and passed downstairs, over the street, and into the overseer's office. Before opening communication with the gentlemen in the overseer's office, the lecturer said that the sounds could only be heard by the persons who had hold of the speaking apparatus. Bell's telephone was perfect as far as it went, but the audience could not hear the answers. Edison's telephone, on the other hand, possessed this advantage, and singing and music could be heard distinctly a good distance off by persons in the room. Questions were then put through the telephone by the lecturer to a gentleman in the overseer's office, and were correctly answered. At the close of the lecture, which was very instructive and interesting, a vote of thanks was passed to the lecturer and chairman.

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THE IMPROVEMENTS SCIENCE CAN EFFECT IN OUR TRADES AND IN THE CONDITION OF OUR WORKMEN.*

BY PROFESSOR W. E. AYRTON.

Trade is bad, horribly bad! The causes of this depression, which meets us on every side, it is not difficult to ascertain—inability to compete with the foreigner in the production of what England consumes, combined with inability to trade economically in his own markets. We cannot, for example, now grow corn or rear cattle as economically as we can get them from America; so that while our land produces ten million quarters of wheat a year we import as much as thirteen millions, whereas thirty years ago we grew fourteen millions (more, in fact, than at present), and imported only four million quarters per annum.

On the other hand, the Americans can manufacture machinery cheaper than we can sell it to them, in consequence of their high import duty of about 30 per cent.

We might say that this state of things arose from their having on the other side of the Atlantic vast pasture lands, a good climate, and protection; while we are cramped for room, inundated with rain, and luxuriate in the blessings of Free Trade.

It is not, however, only the demand abroad for English commodities that we see slowly dying away, but we find that even in our own country we are being gradually undersold in those productions which depend not on pasture lands, not on climate, but on the use of labour-saving machinery—the result of human ingenuity.

Our disappointment in witnessing the gradual disappearance of the foreign market for our manufactures may possibly be alleviated by our belief that the example we are setting of perfect freedom in trade will be ultimately for the world's good. But no ray of consolation can cheer the remembrance that our Coventry ribbon trade, that once famous industry created by ourselves, has well nigh departed to Switzerland in company with the silk weaving industry of Lyons and Spitalfields. The Clerkenwell mechanic sees with no feeling of national pride, the American machine-made watches pressing on his heels in the march of time. Even our trade in the bending of umbrella and stick handles is rapidly crossing the Atlantic, and several of our chemical industries are being absorbed by the Continent.

And what about those devices, those Yankee notions, as we call them, in which machinery replaces the old cumbersome and uneconomical hand labour—the sewing machine, the type-writer, for clear and rapid correspondence, the electric pen, for superseding lithography, duplex and quadruplex systems of telegraphy for multiplying the carrying capacity of a telegraph line, and that instrument for dispensing even with messengers, the telephone. Why, not only do these come to us now from America, but it was in that country that they all sprang into existence, with many brothers and sisters like themselves. I shall, no doubt, be answered that it was to that country that they all owed their birth, because American labour is so dear, and, consequently, some means must be found to economise it. You might imagine from this there was in America a national evil—dear labour—and that machinery had to be devised to overcome its ill effects. But do high wages necessarily mean large selling price of manufactured goods? What foremen in this room, wishing to turn out articles well and cheaply, would prefer employing an ignorant Indian labourer at say twopence a day wages, instead of an English mechanic, with his knowledge of tools, at six shillings a day. So, in the same way, a highly-paid American workman may, with his most ingenious labour-saving machinery, undersell the English in their own market. One of the things, therefore, which England requires, in order to regain her old commercial supremacy, is smaller cost of production of manufactured articles, a condition of things which, I think, you see, is not at all incompatible with higher wages.

In my British Association lecture to the workmen of Sheffield, this year, I have experimentally shown how an enormous economy can be effected in the consumption of coal, and, consequently, in the cost of generating power, and in the working of the metals, as well as in the expense of warming and lighting your buildings, by the employment of very large steam engines and of natural sources of power, such as streams and waterfalls, and by conveying, through the agency of electricity, this power to the distant places where it was required to be used. For water power, if sufficiently far away from a town, is often worth little or nothing, since the cost of conveying the work done on the spot over the hilly country to the markets more than compensates for the economy of using water instead of steam; but the waterfall, if utilised for transmitting power into the towns by electric currents, becomes much more economical than burning coal. Again, as I explained to my audience, work done by distributed power from a very large steam engine, would be much cheaper than using a number of small steam engines if only the power could be distributed without the great waste which always accompanies the friction of shafting, leather-belts, tooth-wheels, &c. Now, if by means of what is called a dynamo-electric machine, we convert the work done by the one large steam engine into electricity on the spot, and convey, by means of wires, this electric current to different points, and there, with dynamo machines worked backwards, we re-convert it into motive power, then the loss of energy by friction, &c., can, with the special form of working I explained, be reduced to something like 30 per cent.

As a small illustration of what I mean, I will show you the following experiment:—When I turn the handle of this machine, my muscular energy is converted into electricity; the food that I have eaten is burnt up in my body, and its equivalent—a current of electricity—is produced. This electric current, by means of the copper wires before you, is conveyed across the hall to that other machine, similar to the one I have here. In that distant machine, the electric current is converted back again into mechanical motion, and the work given out there can be practically made use of—for turning, for example, that sewing machine.

In the same way, but on a much larger scale, we ground knives on the platform of the Albert Hall, Sheffield, turned in a lathe, sawed thick planks, electro-plated, and lighted the building, the power for doing this being all supplied by a steam engine a quarter of a mile away. Coal was put into the furnace of the steam engine at one end of the long copper wires, and work was given out at the other ends of the wires in the Albert Hall.

But the importance of this principle of the electric transmission of energy, like that of many other simple principles, while grasped by foreign engineers, is almost unknown to the British public. Last year, in order to gain the advantage of ploughing by steam, while at the same time to avoid the disadvantage of pulling a heavy steam engine into rough fields, two French engineers, MM. Chrétien and Felix, ploughed by electricity. A plough was used having two sets of shears, so that it could be used going forwards or backwards without turning. This plough was pulled across the field, first one way and then the other, by a dynamo-electric machine, stationed one on each side of the field. These dynamo-electric machines were driven alternately by an electric current, conveyed to them by wires coming from a third dynamo-electric machine on the hard road some hundreds of yards away, and to which motion was given by a steam engine placed beside it. A photograph, taken on the spot, of the plough, and one of the dynamo machines, I now project on the screen. We will next look at a second photograph, of a drawing of M. Chrétien's electric crane for unloading boats. This also has been successfully employed for several months in the harbour of Sermaize, France, and it is considered that a saving of about thirty per cent. has been effected in the expense formerly incurred for unloading the sugar barrels out of the boats.

When one of our leading telegraph engineers, Dr. Siemens, has urged so strongly the economy of this electric transmission of power, it may appear inconsistent for me to say that the British public do not realise in the least the value of this new principle, and needless for us to fear that their conservatism will throw considerable obstacles in the way of its general adoption, but then we must remember that Dr. Siemens is a German, and was probably educated in a German Polytechnicon, or in some institution realising the value of technical education, and affording the means for imparting it.

At Sheffield it was the economy of utilising the present wasted natural sources of power that exist in our mountain streams that I urged on my large audience; to-night it is the utilisation of even a still more important dormant natural source of power—man's brain—that demands our close attention.

It must sometimes have puzzled you why a successful professional man, one who has no manual skill, no strength of limb, earns, by his work, so much money, and what is higher, so much fame. It must sometimes have struck you as, at the very least, rather hard that while you are toiling from morning to night, day after day, to gain only enough to live on, another, by the mere efforts of his thought, amasses a fortune. But you, no doubt, regard it as quite fair that a skilled mechanic should receive higher wages than a navvy. For you say that although he has eyes and arms, like yourself, and is, perhaps, the stronger of the two, still you can use your powers with a skill of which he knows nothing. Now, just as he has muscular strength, which, when cultivated, means wealth to himself and his country, so you have brain power, which only requires education to fit it to do useful work. But you will say, am I not forgetting you have all been to school, and have received an education at least as good as is given in the Board schools. Consider, however, what is taught in these schools where masses have to be educated. Is there time to teach reflection, to foster the reasoning power? Is there that training given you which should make you unwilling to follow any special routine method in your trade, unless you are convinced it cannot be improved on? And can you expect it to be otherwise when the boys and girls leave at twelve or thirteen years old, when the main object of the teacher, who is paid by results, is to cram the young until they are heavy enough to drop through the examining machine, when occasionally the teaching is necessarily confined to the three R's, solely because the Government inspector finds that other subjects are—well, a little beyond his limited attainments. Again, what is the feeling boys and girls have at the national schools? If they succeed in their lessons, they look forward to becoming pupil teachers; but if prizes do not fall to their share, they feel that teaching is not for them, and fall back on a trade; but how very few, if any, ever look to their studies as a means of making them educated workmen instead of mere copying machines.

The consequence is that, when a lad is first apprenticed, he is merely an errand boy, or fag, being fit, in fact, for little else. Subsequently, he is posted in one of the departments of the manufactory, his instructor being the man under whom he works; but this man, having his own work to attend to, has not time to teach, and, even were it not so, he could only show the boy the manual operations.

When the piece of work on which the apprentice has been engaged is finished, it has to pass the foreman of the department; generally, a man who, through honesty, sobriety, and manipulative skill, has risen from the ranks of the workmen, and whose education has been of a character similar to those around him. The foreman's duties, of course, leave him no time—even if he were competent—to give instruction, and thus the lad goes on, probably working, quite mechanically, at only one small branch of his trade. In time, he becomes a journeyman; he may become a foreman, to govern others. Thus, the "rule of thumb"—viz., each man working as his shopmates do—proceeds, and thus ignorance of principle has been carried on from one generation to another. And things go on remaining very much as they are, merely because we have never seen them otherwise.

The man or woman, then, instead of becoming an agent far above any machine—in that there should be the possession of the reasoning power, which is a quality of no machine—frequently finds him or herself, mentally, infinitely inferior to Babbage's calculating engine; bodily, quite unable to work with the accuracy and speed of, say, an automatic lathe for turning gun-stocks; and, from having a knowledge of only one narrow department of one restricted industry, is quite at the mercy of the fluctuation of trade for the means of subsistence.

But, do not let it, for the moment, be thought that I am regretting the Education Act of 1870, or am, in the least, blaming the necessary course taken by the School Boards, since nobody is more alive than they are themselves to the incompleteness of the present education of the English artisan. That may be seen from this year's report of the Educational Endowments Committee, in which it is recommended that the City Parochial Charities shall be employed for the establishment of technical schools, to be attended by boys and girls for the two years after leaving the existing schools, that is, during their fifteenth and sixteenth years. It is not necessary on the

* Inaugural Lecture at Cowper-street Schools in connection with "The City Guilds Institute."

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present occasion to refer to the suggested curriculum of such technical schools, beyond saying that it appears to be complete.

It ought to be tolerably clear to every man, that it is important for him to have a good knowledge of the fundamental principles that govern the processes employed in his own trade. For example, when it is remembered what great mechanical differences are produced in iron by the admixture of even small quantities of carbon and by varying the temperature of hardening and annealing, the steel manufacturer will see at once the importance of the study of chemistry to him. In these pieces of steel which I hold in my hand, and which are all quite soft now, the smallest amount of carbon is less than one-tenth per cent. and the largest amount only one-and-a-half per cent., but if I heat all three pieces red hot and plunge them into cold water, the first, you see, remains quite soft, while the second has become springy, but the third is glass hard, so that it shivers to pieces when I try to bend it. But if I had kept them heated white hot for some time, I should have burnt out the carbon, removed the steely nature, and spoilt them. If, again, after heating the specimens of steel red hot, I had cooled them very slowly, they would, as you all know, have been found each of them quite soft as they were originally. Now, many of us believe that steel is far better for our bridges than iron, but the fact that such very slight differences in the chemical composition and the mode of cooling change so marvellously the mechanical strength without materially altering the weight or the general external appearance of the material, renders any system of testing the quality of the completed girders a difficult problem, and so while on the one hand we are still chary of using steel for bridge purposes, on the other hand the chief manufacturers and chemists are closely turning their attention to the difficult problem of producing steel in large quantities of identically the same chemical and mechanical quality throughout.

So, in the same way, a man engaged in telegraphy, or in any of the various trades connected with electricity, understands the importance to himself of a knowledge of electricity, for he has such facts constantly forced on him as that the difference of the hundredth of an inch in the position of a wire means the difference between a telegraph line in good working order and a total interruption. For example, this electro-magnet which we have on the table has now the power of holding up masses of nails, because an electric current is flowing round its two arms, but if I make a breach in the wire, and keep the two ends separated by even an exceedingly small distance, or if I even press the ends together, leaving, however, a bit of paper or some dirt between them, the electric current is so much weakened that the electro-magnet, as you see, has practically quite lost its power.

Or, again, such facts that metals expand when heated, as you see does this brass ball, so that it will not pass through the brass ring it slipped through when cold, are of importance to every wheelwright, to every caster in metals, &c.

But something more than mere special knowledge is of importance to each man, for the object of education is to develop the mental powers; the acquisition of knowledge I regard as of but quite a secondary importance. Let a man but acquire the art of learning one subject properly, and the groundwork of his education is to a great extent completed, since he will naturally afterwards be always seeking for knowledge from books, from teachers, from nature, in all those branches which at any time may be of importance to him.

It is of much importance that a correct notion of the real aim of education should be impressed on you to-night, when we are here to inaugurate the commencement of that wide scheme of technical education which the City and Guilds of London have, after mature deliberation, generously seen fit now to enter on. In the future we hope to have special classes for a variety of technical subjects, and we shall look to you, guided by your own wants, to choose for us to a great extent what those subjects shall be; but just for the present we must be contented with only a few branches of technical education. Do not, however, run away with the mistaken notion that because I commence my first course of lectures on Monday next, in this building, on "Some of the Practical Applications of Electricity and Magnetism," that, therefore, if you are a watchmaker, or if you are a boiler-fitter, or if you are a coach-builder, you can have no concern with what will be taught. Do not say I shall never put up an electric bell; and, as for electric lights, why, in these hard times, I have hardly money enough to pay for tallow candles. If I were merely going to explain to you how an electric bell was made, and how it could be fitted up in the cheapest and, commercially, best way; or if, again, in my lectures after Christmas, on "The Elementary Principles of Mechanics, as Exemplified in our Clocks and Watches," I was merely going to tell you more dodgey ways of making cheaper watches; you might well say, if your particular trade was not concerned, "That's no good to me," and stay away. But, when I tell you that, from the wide range of technical physical subjects from which the choice had to be made, electricity was selected to start with because it was a subject that had been so prominently before you of late, and the mechanical science of watches has been advertised to follow it because a watch is a machine you nearly all of you possess, and can, therefore, examine for yourselves; and when I assure you that the fundamental truths that will be elucidated by experiments from these branches of inquiry will be of no less importance in the advancement of carpentry, printing, and turning than for improvements in electro-plating, watchmaking, and the allied trades, you will see that coming to these lectures is a duty you owe to yourselves and to your country, and you will conclude, I hope, very many of you, that "since the City is generous enough to offer its money to help my education, I have ambition enough to come and learn."

[TO BE CONTINUED.]

TRAFFIC RECEIPTS FOR OCTOBER, 1879.

Companies.	Oct. 1879.	Oct. 1878.	Incrse.	Decrse
Cuba Submarine Company	3,000 estd.	2,835	165	—
Direct Spanish Telegraph Company	1,371	1,107	264	—
Direct United States Telegraph Company	26,830 estd.	—	—	—
Eastern Telegraph Company	50,251	41,678	8,573	—
Eastern Extension Telegraph Company	31,419	23,393	8,026	—
Great Northern Telegraph Company	21,987	—	—	—

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Nov. 5.		Business Done Week Ending Nov. 5. Highest.	Lowest.
Anglo-American Ordinary	56¾,	7	57½	55
Do. "B"	82¾,	3¼	83¼	80⅝
Do. "A"	32½,	¾	33	30½
Brazilian ex div.	7 3-16,	5-16	7 5-16	7⅛
Cuba	7¾,	8¼	—	—
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	11,	½	11½	11
Direct United States ex div.	10½,	¾	10¾	10¼
Eastern	8¼,	⅝	8⅝	8⅛
Do. Six per Cent. Debenture	103,	6	104	103½
Do. Five per Cent. do	103,	5	104	103⅝
Do. Six per Cent. Preference	12 1-16,	3-16	12¼	12⅛
Eastern Extension	8 7-16,	9-16	8 9-16	8 5-16
Do. Six per Cent. Deb.	107,	10	108½	108½
German Union	7¼,	¾	7¾	7½
Globe Telegraph and Trust	5 1-16,	3-16	5 3-16	4 15-16
Do. Six per Cent. Preference	11⅛,	¼	11¼	11
Great Northern	8⅜,	⅞	8⅞	8 11-16
Indo-European	22½,	3½	22⅞	22⅞
Mediterranean Extension	2¾,	3¼	—	—
Do. Eight per Cent. Preference	9¾,	10¼	10⅛	9⅞
Reuter's	9,	10	9 13-16	9 13-16
Submarine	225,	30	—	—
West India and Panama	1¼,	½	1⅜	1 5-16
Do. Six per Cent. Preference...x d.	7¼,	¾	7½	7¼
Western and Brazilian	4,	¼	4⅛	3 9-16
West. Union Seven per Ct. 1st Mt. x d.	120,	25	—	—
Do. Six per Cent. Sterling	105,	7	—	—

Electric Light Reflectors.—P. E. Chappuis, Manufacturer, 69, Fleet-street. —[Advt.]

THE INDO-EUROPEAN TELEGRAPH COMPANY (Limited), 16, Telegraph-street, London, E.C.
REMOVAL.
The CENTRAL OFFICES of this Company will shortly be REMOVED from 16, Telegraph-street, E.C., to 18, Old Broad-street, E.C. Due notice will be given of the date of removal.
W. ANDREWS, Manager.

TO ENGINEERS and Others.—The Managers of the Metropolitan Asylum District are prepared to receive TENDERS for ENGINEERING and other WORK required at the ASYLUM for IMBECILES, Darenth, near Dartford, Kent, consisting of fitting work in laundry and boiler and engine house, laundry fitments, steam boilers, engine, pumps, &c. Copies of plans and specification, prepared by the architects, Messrs. A. and C. Harston, of 15, Leadenhall-street, E.C., may be obtained at the Offices of the Managers, 37, Norfolk-street, Strand, W.C., on payment of a deposit of five guineas, which will be returned to persons sending in *bonâ fide* Tenders and returning specification and plans. Tenders (on a form which will be supplied) must be delivered at the said offices by or before Four o'clock on WEDNESDAY, November 12 next. The Managers do not bind themselves to accept the lowest or any Tender.
By order, W. F. JEBB, Clerk.
37, Norfolk-street, Strand, W.C., Oct. 22, 1879.

ELECTRICAL AND EXPERIMENTAL APPARATUS.
MR. J. C. STEVENS has received instructions from the BRITISH TELEGRAPH MANUFACTORY COMPANY (LIMITED) to SELL by AUCTION, at his Great Rooms, 38, King-street, Covent Garden, on FRIDAY, December 5, at half-past 12 precisely, the STOCK, PLANS, MATERIALS, and INSTRUMENTS, belonging to some of their departments; they include many kinds of electric, telegraphic machines, and other scientific apparatus, and the implements and materials for making the same. Also many experimental and perfected instruments connected with the inventions of Wheatstone, Morse, Pelletier, which would be interesting and useful for colleges, museums, and lecture rooms. Gramme light and plating machines, lathes, tools, anvils, vices, wire, materials and chemicals for batteries, magnets, galvanometers, bridges, rheostats, A B C instruments, cyrtographs, calculating machines, electric clocks, magnets, bells and pulls, lightning dischargers, &c., &c. May be viewed after 2 o'clock the day prior and morning of sale, and catalogues had.

ESTABLISHED 1851.
BIRKBECK BANK.—Current Accounts opened according to the usual practice of other Bankers, and Interest allowed on the minimum monthly balances. No commission charged for keeping Accounts.
The Bank also receives money on Deposit at Three and a Half per Cent. Interest, repayable on demand.
The Bank undertakes for its Customers, free of charge, the custody of Deeds, Writings, and other Securities and Valuables; the collection of Bills of Exchange, Dividends, and Coupons; and the purchase and sale of Stocks and Shares.
Letters of Credit and Circular Notes issued for all parts of Europe and elsewhere.
A Pamphlet, with full particulars, on application.
FRANCIS RAVENSCROFT, Manager.
Southampton-buildings, Chancery-lane.

The Birkbeck Building Society's Annual Receipts exceed Four Millions.

HOW TO PURCHASE A HOUSE FOR TWO GUINEAS PER MONTH, with immediate Possession and no Rent to pay. Apply at the Office of the BIRKBECK BUILDING SOCIETY.

HOW TO PURCHASE A PLOT OF LAND FOR FIVE SHILLINGS PER MONTH, with immediate possession, either for Building or Gardening purposes. Apply at the Office of the BIRKBECK FREEHOLD LAND SOCIETY.
A Pamphlet, with full particulars, on application.
FRANCIS RAVENSCROFT, Manager.
Southampton-buildings, Chancery-lane.

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NOTES.

Statue to Galvani.—On Sunday, Nov. 9, a statue of Galvani was unveiled at Bologna.

City Guilds Institute.—We are informed that over 1,300 people attended Professor Ayrton's inaugural address, and that over 70 members have joined the regular classes. We trust that ere long the 70 regular members will increase to 700.

Direct Spanish Cable.—The direct cable communication with Spain, *viâ* Bilbao, which has been suspended in order to remove a fault from the cable, is now fully restored. Telegrams should be handed in at 106, Cannon-street, or at any postal telegraph office.

The Albert Hall.—The electric light, which was used last winter for the illumination of the Albert Hall on grand concert nights, has been discontinued; and on Thursday, at the opening performance for the present season of the Royal Albert Hall Choral Society, gas was again used for the lighting of this vast interior.

Carbon for Electric Lights.—Mr. Gray has taken out new patents for this purpose. He reduces carbon to a fine powder, and washes it in alkaline or acid solutions, and then mixes with sugar, molasses, and other adhesive substances that will liquefy with heat. The mixture is afterwards moulded in a press, and submitted to a high temperature in order to carbonize the saccharine matter.

The Electric Light in "The Times" Office.—Within the last few days the electric light has been introduced into the "making-up room," a large apartment on the ground floor of the east side of the quadrangle in Printing House-square. The illuminating power is most effective, "artificial daylight" being shed over the whole interior. The electric light has for some time past been in operation in the machine department of the establishment.

The Telephone in the Nursery.—In many of its aspects, the telephone is, perhaps, the most interesting of modern inventions. It comes home to men's business in the telephonic exchange, and as in the following pleasing incident, from an American source, equally to their bosoms. In the United States friends have their houses placed in telephonic communication, and they also communicate with the butcher and baker by telephone. A proud grandmamma, we are told, who had only just been promoted to the honours of that happy relationship, was awakened in the dead of night by the inexorable bell. "Mamma, dear," came to her the frightened voice of her beloved but inexperienced daughter, "I'm sure bady has the croup. What shall I do with it?" Grandmamma replied that she would call the family doctor, and be with her anxious daughter in a moment. She awakened the doctor and told him the terrible news she had learnt from her daughter. He in his turn requested to be put in telephonic communication with the too anxious mamma. "Lift the child to the telephone, and let me hear it cough," he commands. The child is lifted, and it coughs. "That's not the croup" he declares; and he declines to leave his house on such a small matter. He advises grandmamma also to stay in bed; and, all anxiety quieted, the trio settle down happily for the night.—*Iron.*

The Electric Light at Chester.—The Hydraulic Engineering Company (Limited), of Charles-street (Brook-street), have just adopted the electric light for their new erecting shop. This shop is 120 feet in length, by some 40 feet in width, and 40 or 50 feet in height. It is fitted with a steam travelling crane capable of lifting great weights. At the time of inspection the men were working upon some hydraulic machinery under the electric arc, which gave a light resembling in its colour and its shadow the light of the moon, but of great clearness and intensity. The light was placed against the wall of the near end, and at the further end of the shop small print and pencil writing were distinctly visible and easily readable. The lamp adopted is the Serrin lamp, and the electric machine employed is the Gramme. Messrs. Crompton and Fawkes, of London, have laid down the apparatus, and Mr. Subworth, electrician, has superintended its fitting. The light was very steady, and the men were able to work uninterruptedly. In the adjoining workshop gas jets were profusely employed at the various machines, as well as two central dome lights of eighteen burners each, but the effect was twilight compared with the almost "broad day" of the erecting shop. The power in this case costs practically nothing, as the additional strap which turns the Gramme machine at a nominal speed of 900 revolutions per minute makes no practical difference, the loss of power being imperceptible. The power being, therefore, put down as costing nothing, it is anticipated that the lighting of this shop will be effected at half the cost which would be incurred were gas employed. The Serrin lamp burns five hours. In places where light is required in corners which are in shadow, as in foundry work, small hand reflectors meet all the difficulty, but in engineering work this resource is scarcely ever needed. Certainly the Hydraulic Company may be congratulated on having practically succeeded in turning night into day.

Another Telephone.—An improved form of instrument, having combined with it a telephonic call or signalling apparatus, has been invented by Dr. A. M. Rosebrugh, of Toronto. It is constructed as follows:—To the telephone diaphragm, which is connected with a mouth-piece in the usual way, a cylindrical piece of magnetised steel, a quarter of an inch in diameter and one inch in length, is attached. The free end expands suddenly near the end to a diameter of half an inch. This magnetised cylinder passes loosely through the centre of the soft iron core of an electro-magnet, which is secured to a plate placed at a distance of a quarter of an inch from, and parallel with, the diaphragm. A space or chamber is enclosed between the diaphragm and the plate to which the electro-magnet is attached, and from this space a tube leads to another and elastic tube terminating in an ear-piece. The free end of the magnetised cylinder projects a quarter of an inch beyond the core of the electro-magnet, and the extremity is adjusted to a very short distance within one pole of the fixed permanent magnet, the pole being of opposite polarity to that of the free end of the magnetised steel cylinder. The action of the telephone is as follows:—When the diaphragm is vibrated by the voice, the vibrations are communicated to the magnetised steel, the free end of which is in close proximity to the

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fixed magnet; this varies the magnetisation of the core of the electro-magnet, and an undulatory current of induced electricity is developed in the coil, and through the circuit of which it forms a part. This current, acting upon the electro-magnet of a receiving telephone of similar construction, reproduces in the diaphragm of that instrument the vibration of the first instrument. If the diaphragm is composed of soft iron, it should be adjusted close to the core of the electro-magnet; the induced current in the coil is thereby strengthened, and the telephone can be used on a line of higher resistance. The apparatus as above described constitutes a transmitting or speaking instrument and a receiving instrument in one, both surfaces of the diaphragm being utilised during conversation, the mouth piece being held to the mouth, so that the anterior side of the diaphragm receives the vibrations caused by the voice, while the ear-tube is kept constantly to the ear, which receives the sound vibrations from the posterior side of the diaphragm. If a horse-shoe magnet is used, two electro-magnets, and also two small magnets attached to the diaphragm may be used, by which means the vibrations of the diaphragm intensity of the induced current will be increased. The signalling-apparatus is constructed as follows:—On the side of the magnets opposite to that of the telephone electro-magnets, one or more electro-magnets or induction coils are made to rotate or to move to and fro by suitable mechanical means. These induction-coils are made to move very near the poles of the magnets, in such a manner that their cores will alternately be magnetised and demagnetised, so as to cause induced currents in the coils, and in the line with which they are connected. A single or double pair of electro-magnets are added, and provided with an armature vibrating between the poles of the electro-magnets, and connected with a striker, provided with an adjusting spring to oppose the action of the electro-magnets. The armature is magnetised steel, or the electro-magnets are polarised. The induction-coils are also provided with a commutator, or with an automatic current-changer, which may or may not be used at pleasure. The transmitting and receiving instruments are made alike, and are connected in the usual way; when the induction-coils are rotated, or moved to and fro, near the poles of the magnet, the induced current affects the signalling-coils, and the bells are rung both in the transmitting and in the receiving instruments. By breaking the current by means of a press button, and again closing it, and repeating a definite number of times, a definite signal can be given. By using the automatic interrupter, a signal can be given on the receiving telephone diaphragm. The instrument is also provided with a switch for shunting the signal while speaking, and the telephone while signalling, and also with a press-button for interrupting the current while signalling.

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Electroplate, Nickel, and German Silver Goods.—Since the upward movement in the metal market set in, some six weeks ago, there has been a very decided improvement in the demand for nickel and German silver, both for home and export; but the expansion of business has not been so marked in finished goods. The leading local refiners report larger orders for rolled metal from the United States, France, and Japan, than they have experienced for many years past, and if those orders could be accepted as the measure of consumptive requirements, the trade would be in a hopeful state. It does not appear, however, that English electroplaters and manufacturers are using more metal than is customary at this season, when there is always a certain increase of demand for table-ware and fancy goods in anticipation of the requirements of the gift season, and the general impression is, therefore, that the run upon German silver is to a great extent speculative. Exception, however, must be made in favour of the orders from the United States, where the electroplating branch appears to be participating in the general improvement of trade, and Japanese requirements also are probably of a *bonâ fide* character, to meet the demands of the native manufactures of cups, hinges, locks, cabinets, pans, &c. Since the discovery of the New Caledonia nickel-mines, and the development of the dry smelting process by Sir Josiah Mason, production here has so greatly outrun demand that the metal has been selling at something under cost price, or, say, 2s. 6d. to 2s. 9d. per lb. Within the last week or two the value has risen some 2d. or 3d. per lb., and if the present demand continues the list price will probably be raised to 3s. per lb. for ordinary nickel, and about 5 per cent. less for that produced by the dry process. Nothing but the keenness of competition between the old and the new refining houses keeps the metal at its present low level, and in the not improbable event of a truce or arrangement between them both nickel and German silver must rise to a permanently higher value, limited only by the conditions of German competition. At present the Germans are practically out of the market, and English nickel, quality for quality, connot be touched at the price. There is one German alloy, however, now in the market of which great things are anticipated. It is called nickel steel, and consists of a combination of those metals in certain patented proportions, which yield a product combining the whiteness of the best nickel with the hardness of the finest tempered steel. Should this invention prove commercially practicable, as competent metallurgical chemists believe, it can hardly fail to revolutionise the nickel trade, by lifting it at once from a luxury branch to one of strict utility. The new alloy is said to be admirably adapted for cutlery, tools, machinery gun-barrels, &c., and though the initial cost would doubtless be heavier than that of ordinary steel, it would be recouped in time by the greater durability of nickel steel, and its freedom from oxidisation. Another alloy which is slowly winning in this country the favour it has long enjoyed in France is nickel bronze, produced by the Société Française Anonyme, of Paris, under the patent of M. Jules Garnier. This bronze is white as nickel itself, homogeneous, stronger than copper, inoxidisable, and cheap, costing little more than plated copper, which it greatly surpasses in hardness and durability. At the late Paris Exhibition, where the metal was introduced, the company took a gold medal, and they have this year gained a diploma at the Industrial Exhibition of Marseilles. For locks, door and window furniture, lighting and heating apparatus, chains, arms, buckles, coach and saddlery fittings, optical and mathematical instruments, clocks, art bronzes, &c., this metal is extensively used abroad, and there ought to be a great future for it in this country. For the most part, however, our manufacturers are well content to work in old grooves, and prefer to cater for an existing demand rather than incur the trouble and risk of creating and fostering a new taste. Spoons and forks, and suchlike necessaries, are always in request, and it is easier and safer to go on manufacturing these in the old way than to launch out into new and costly experiments. Just now business in the spoon and fork department is fairly good, both for home and export. Orders from Melbourne and the Cape have been specially good of late, and the home trade is improving. Messrs. Elkington are busier in all departments than they have been for a long time past.

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JAMES CLERK MAXWELL.

James Clerk Maxwell was born in 1831, the only son of John Clerk Maxwell, Esq., of Middlebie. His grandfather, Captain James Clerk, was a younger brother of Sir John Clerk, of Penicuik, and his two sons were the Right Hon. Sir George Clerk, Bart., and the above-mentioned John Clerk Maxwell. Sir George Clerk succeeded to the estate of Penicuik on the death of Sir John Clerk; while John succeeded to the estate of Nether Corsock, part of the Middlebie estate which had come into the possession of the family through marriage in a previous generation with its heiress, Miss Maxwell. Along with the estate John Clerk assumed the family name of Maxwell. John Clerk Maxwell married Miss Cay, of Edinburgh, who died when her son James was eight years old. After this he lived a retired life, devoting himself to the care of his son and the improvement of his estates.

James Clerk Maxwell received his early education in the Edinburgh Academy, where he gained the medal for geometry in 1845, and the mathematical medal in 1847. Thence he proceeded to Edinburgh University, where he studied under Professor Kelland and Principal Forbes. In 1849 he presented to the Royal Society of Edinburgh, through Prof. Kelland, a paper on the theory of rolling curves. In 1848 his uncle, John Cay, introduced him to Wm. Nicol, whose experiments with polarised light delighted him beyond measure. He at once set about making a polariscope with cardboard and glass, and by means of a camera lucida he faithfully depicted in water colours the figures manifested by samples of unannealed glass which he himself prepared. These water colour drawings he sent to Nicol, who was so pleased with them that he sent in return a pair of prisms of his own construction. These prisms were very highly prized by Professor Maxwell, and are now in the apparatus room of the Cavendish Laboratory. From the study of unannealed glass he was led to the consideration of the equilibrium of elastic solids, and his paper on this subject was read before the Royal Society of Edinburgh on February 18th, 1850. In October, 1850, he came to Cambridge, where he entered Peterhouse; here, however, he was unable to find congenial society, all the men being either classical men or pure mathematicians, and he could meet with but little sympathy in his physical work. He accordingly, with the concurrence of his college tutor, migrated to Trinity, which he entered on December 14th, 1850. Here he soon became the leader of a set of men who appreciated his talents, and he no longer found life dull at Cambridge. In 1854 he took his degree as second wrangler, and was bracketed first for the Smith's Prize. His paper on "The Transformation of Surfaces by Bending," was read before the Cambridge Philosophical Society in March, 1854. In 1855 he was elected to a fellowship at Trinity, and in 1856 was appointed Professor of Natural Philosophy in Marischal College, Aberdeen.

In 1855 he wrote his papers on "Faraday's Lines of Force," and he used strongly to recommend students to study Faraday's ideas on this subject. In 1857 he obtained the Adams Prize in the University of Cambridge for his "Essay on the Motions of Saturn's Rings." The mechanism by which he illustrated this paper is now in the apparatus room of the Cavendish Library.

In 1858 he married Katherine, daughter of Principal Dewar, of Marischal College, and retained his Aberdeen Professorship until the fusion of Marischal and King's College, when he received a pension from the Crown.

It was while at Aberdeen that Professor Maxwell constructed his colour top, and pursued his investigations on the theory of compound colour, and the relations of the colours of the spectrum, which, in 1860, gained for him the Rumford Medal of the Royal Society. In the same year he succeeded Professor Goodeve as Professor of Natural Philosophy and Astronomy in King's College, London. While holding this professorship he was busily engaged as a member of the British Association Committee in determining the absolute unit of resistance, and in his experiments on the viscosity or internal friction of the air and other gases, the results of which were made known to the Royal Society in the Bakerian lecture read on February 8th, 1866. His paper on a "Dynamical Theory of the Electro-magnetic Field" was read before the Royal Society on Dec. 8th, 1864. After the death of his father he retired to his estate at Glenlair, Kirkcudbright, in 1865, where he resided until he was invited by the Senate to accept the chair of Experimental Physics in the University of Cambridge in 1871. In 1866 he presented to the Royal Society a paper on "The Dynamical Theory of Gases," and in 1868 his paper on a "Method of Making a Direct Comparison of Electrostatic with Electro-magnetic Force" was read before the same society. After accepting the chair of Experimental Physics at Cambridge, he personally superintended the erection of the Cavendish Laboratory, which, together with its equipment of apparatus, was presented to the University by the Duke of Devonshire. All the contrivances which rendered the Cavendish Laboratory so useful for experimental work are due to the forethought and supervision of Professor Maxwell. Among his most recent papers is one upon stresses in rarified gases due to inequalities of temperature, read before the Royal Society on April 11th, 1878. The last article he wrote was "Harmonic Analysis," for the "Encyclopædia Britannica."

During last spring Professor Clerk Maxwell did not enjoy his usual health. After his departure for Scotland in June he became weaker and could take no solid food. Towards the end of September he became much worse, and was recommended by his physicians to return to Cambridge. Under the care of Dr. Paget his health seemed at first to improve, but he continued to get weaker. During the latter part of his illness Dr. Humphrey occasionally visited him in conjunction with Dr. Paget, but it was plain that medical skill could only palliate and could not cure his disease. He died at noon on Wednesday, November 5th. Except that physical weakness sometimes made thinking wearisome, Professor Maxwell retained the full powers of his mind to the last. On Monday, November 10th, the first part of the burial service was read over his body in Trinity College Chapel at 4:45 p.m., in the presence of several of the heads of houses, professors, and other members of the electoral roll. The assembly followed the bier to the great gate of Trinity, whence the remains were conveyed to Scotland, to be interred with the other members of his family at Corsock.

As a teacher Professor Maxwell was wonderfully admired by all his pupils who were true students of science. He was not a popular lecturer, for his sentences contained too deep a meaning to be appreciated by the casual listener, but perhaps there has never been another who could, in so few words, suddenly illuminate the subject about which he conversed, and then, by a rapid flight of the imagination, carry his listener into a new field, where every object was familiar, but the exact counterpart of the more abstruse subjects previously considered. It is impossible in a short sketch like the present to give a review of his contributions to science, or even to mention the titles of all his papers. It is to be hoped that they will some day be collected and published in an available form. His largest work is his "Electricity and Magnetism," the second edition of which is now in the press. His "Theory of Heat" and "Matter and Motion" are both models of scientific writing, and are calculated to greatly raise the standard of elementary teaching. The last great work he completed was the publication of the electrical researches of the Hon. Henry Cavendish, from MSS. in the possession of the Duke of Devonshire.

But James Clerk Maxwell was not simply a man of science. He was well acquainted with all the current literature of the day, and with every subject that forms part of a liberal education. He had a great genius and love for poetry, a ready wit, and a strong sense of humour. All these characteristics are distinctly marked in many productions of his pen which have been published in Blackwood's magazine and elsewhere. His love of humour was so apparent that those who were not most intimately acquainted with him frequently found it hard to decide when he was in earnest.

As a Christian gentleman his character was beyond description. His tender consideration for all around him, and his self-sacrificing devotion to those he loved, called forth the wonder and admiration of all who knew him. His simple, firm, Christian faith, based upon no authority of human

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teachers, but upon the results of an earnest and unbiassed search after truth, gave him a peace even in times of most severe bodily pain, which surpassed all understanding.

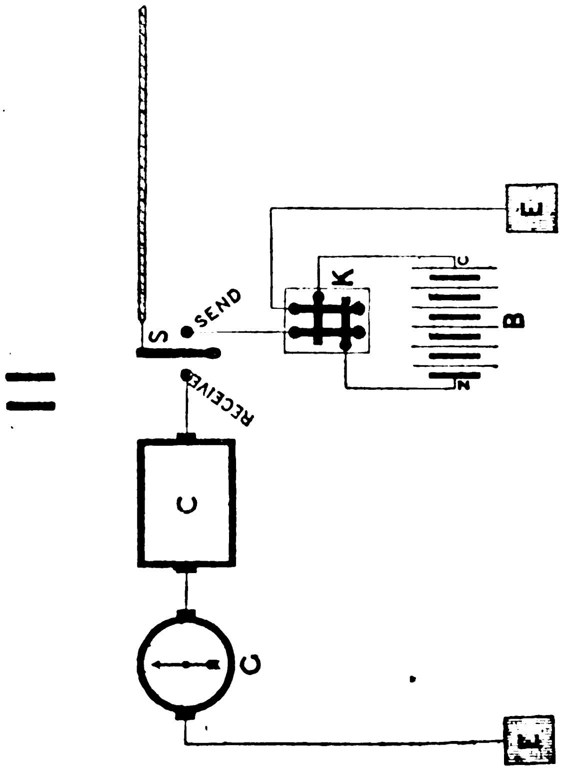
Professor Maxwell was appointed foreign honorary member of the American Academy of Arts and Sciences of Boston in November, 1874; member of the American Philosophical Society of Philadelphia in October, 1875, correspondent in the mathematical class to the Imperial Academy of Sciences at Göttingen in December, 1875, honorary member of the New York Academy of Science in December, 1876; Associate of the Amsterdam Royal Academy of Sciences in April, 1877; and corresponding member of the Imperial Academy of Sciences, Vienna, in August, 1877. In 1872 he received the honorary degree of LL.D. at Edinburgh, and in 1876 the Hon. D.C.L. at Oxford. He was a Fellow of the Royal Societies of London and Edinburgh, and of the Cambridge Philosophical Society. He was elected an Honorary Fellow of Trinity College, Cambridge, in 1872. W. G.

NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONCLUDED FROM P. 285.)

VI.

The arrangement ultimately adopted by Mr. W. Smith for signalling through the Atlantic cable is shown in Fig. 11, in



which C represents a condenser having a capacity equal to 75 miles of the cable, and S a switch by means of which the line was brought directly into contact with a reversal key and battery when signals were to be transmitted; being connected with the condenser only for reception. The arrangements were the same at each end of the cable; the switch being normally on the contact marked "receive," and either operator, when wishing to speak, "switching over" to the contact marked "send," in order to give the call signal, then reverting to "receive" in order to obtain the reply to his call, and lastly again switching over to "send," in order to transmit the communication. "With this simple arrangement," says Mr. W. Smith, "I have seen 25 words per minute received at Valentia from Heart's Content through 1,900 nautical miles of cable, with the most perfect ease. If we consider for a moment what 25 words per minute really mean, we shall be better able to realise the credit due to those gentlemen who are, what is termed, 'good mirror clerks.' For a speed of 25 words per minute, the sender has to manipulate the springs of the key K, so as to make 375 contacts per minute; and the receiver has to distinguish, in the same space of time, the true from the false, in the 750 movements of the small beam of light, which moves either to the right or left on a white strip of cardboard placed before him. This system has now been in use for twelve years on the Atlantic cables, and has been adopted for working all the cables laid during that period, and for speed, simplicity, economy, and accuracy, it has not been surpassed."

The following illustration given by Mr. W. Smith of the simplicity and superiority of this system is probably applicable in equal degree to the previously-described arrangement for signalling, as well as receiving, signals by induction. What, in fact, it mainly proves is the immense advantage under certain conditions of a receiving instrument having the extreme delicacy of the mirror galvanometer. "In 1861 a cable was laid from Malta to Tripoli, from Tripoli to Benghazi, and from Benghazi to Alexandria. The core consisted of 400lbs. of copper and 400lbs. of gutta percha, per nautical mile. The total length of cable laid was 1,330 miles, and the actual speed with the Morse instrument, which was the instrument employed, was 3·2 words per minute. The only way known to increase that speed was to work each section separately. On my return from the Atlantic expedition in 1866, I was requested to proceed to Malta, and apply the system which had proved so successful on the Atlantic cables to the Malta and Alexandria cable. I therefore instructed my assistant, Mr. May, who had so ably discharged the duties entrusted to him while in charge of the shore station at Valentia during the laying of the Atlantic cables, to proceed to Alexandria, and at a certain time, which was agreed upon, to connect to the end of the cable there the arrangement as shown in diagram No. 11. But in this case C consisted of alternate sheets of tinfoil and gelatine, similar to R in diagram No. 9, hurriedly put together. I proceeded to Malta with similar apparatus. On my arrival there I learned that they had not been able to communicate between Benghazi and Alexandria for some days, owing to a fault of very low resistance in that section of the cable. The repairing ship had left Malta, and was supposed to be at work endeavouring to remove the fault. But as no alteration had taken place within a few hours of the time which I had arranged to speak with Mr. May, I requested Tripoli and Benghazi to join the cable through for a definite time at their respective stations; and having connected the instruments as shown in diagram No. 11, with the switch over to 'send,' at my end of the cable, at the appointed time, the call signal was sent at Malta, and, to the surprise of some and delight of all, prompt as an echo came the reply, quite clear and distinct. Now the operators both at Malta and Alexandria had had no practice whatever with the mirror system of signalling, and yet they worked so well that the line was opened the following morning for the despatch of public messages. Unfortunately there were no means of communicating with the repairing ship; and thus, after the cable had been working very successfully, both financially and electrically, for seven days, it was broken by the repairing ship in endeavouring to get at the fault. Had the cable not been broken, it is impossible to say how long it would have been worked, but most probably until, at least, a more favourable time of the year for repairs."

With the fact before us that the speed of signalling through long submarine cables was, in 1867, augmented to an extent that was beyond all expectation, and seems even now almost unaccountable, every circumstance in relation to the introduction of the simple appliances through which this augmentation was brought about becomes of the greatest interest. The relative importance of these appliances, consisting of (*a*) a galvanometer, and (*b*) a condenser, and the possible further improvement to be obtained by the adoption of a system of "curbing" the signalling currents, are also questions which must naturally engage attention on the part of telegraphists. We think that the mirror galvanometer was undoubtedly the most important innovation upon the systems of signalling employed for land lines, and for the earlier and shorter cables. Nevertheless, in the case of long submarine cables, this instrument would be comparatively ineffective without the use of a condenser at the receiving end, at the sending end, or at both ends of the line—unless some system of "curbing" the current were employed. As pointed out by Mr. Varley during the discussion on Mr. Willoughby Smith's paper, the condenser, when used for sending, does in a measure "curb" the signalling current, by producing a reversal at each release of the key. But the condenser is most effective, apparently, when placed at the receiving end of the line; and we are thus led to the conclusion that the main use of the condenser is to limit the quantity of electricity flowing from the cable to produce an elementary signal, and that this action constitutes the secret of its efficacy. Another of its uses is to obviate the effects of earth currents, which are almost entirely inappreciable when the cable is insulated from earth by condensers at each end, and are

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greatly reduced by the employment of even one condenser. In regard to the introduction of this most important adjunct to the mirror instrument, the evidence before us in Mr. W. Smith's paper, which probably embodies nearly the whole of that which is at the present moment available, shows :—

1st. That the use of condensers in connection with cable signalling was suggested in 1862 by Mr. C. F. Varley, who originated and specified the method of *sending* signals by the effect of induction, but failed to specify the effective method of *receiving* signals by induction; since he indicates that the condenser at the receiving end of the cable should in all cases be shunted.

2nd. That Mr. Laws suggested the use of and Mr. W. Smith first practically employed a condenser, as in diagram 10, for obtaining signals through a long submarine cable; these signals not being obtained by the effect of induction, but merely by "tapping" the charged cable of a portion of its charge.

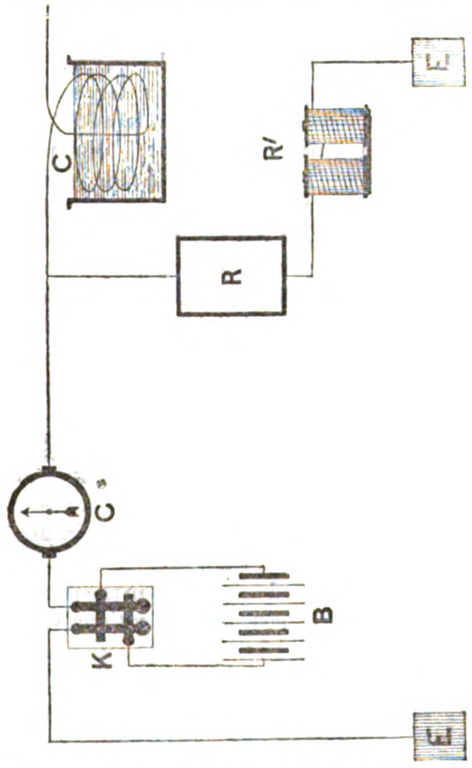
3rd. That Mr. C. F. Varley thereupon suggested a modification whereby signals would be sent by induction in accordance with the method devised by him in 1862.

4th. That Mr. W. Smith finally dispensed with the mode of *sending* signals by induction; but applied a condenser, unshunted, to the *receiving* end of the line; thus originating the system which has been in use for the last twelve years.

We will conclude our notice of Mr. Willoughby Smith's valuable paper by quoting from it his description of a very interesting experiment, in which the "coil current" is made to neutralise the charge of a cable, so that no discharge can be obtained. Suppose, for instance, that the right-hand spring of the key K in the following diagram is depressed, a current from the positive pole of the battery B will flow through the galvanometer to line, and communicate a *plus* charge to the cable C; it will also traverse the resistance R and the electro-magnet $R_{\prime}$, and thus complete the circuit through earth. But it will be momentarily *retarded* by the effect of a current tending to traverse $R_{\prime}$ in the opposite direction to that of the battery current. On releasing the key-spring, a current in the same direction as the battery current will tend to traverse $R_{\prime}$, and will actually traverse it, since the E.M.F. which is generated will cause the charge in C to flow to earth.

"Diagram 15," says Mr. W. Smith, "will make clear to you

15



an experiment in which the induced magnetic charge totally neutralised the charge from the battery, so that no discharge could be obtained. K is an ordinary reversing key, G an astatic mirror galvanometer, B a battery of five Menotti cells, C three miles of ordinary No. 7 gutta percha covered copper wire in one coil, immersed in water. R a resistance coil of 7,100 ohms, R' an electro-magnet, the resistance of the wire of which was 854 ohms. By increasing or diminishing the resistance of R, the true discharge of the induced current could be obtained at will, one unit either way being sufficient to appreciably affect the balance. In another experiment eighty-five knots of gutta percha covered wire in coils were immersed in water in iron tanks and joined in one continuous length. The absolute resistance of the conductor was 626 ohms, and the absolute electrostatic capacity twenty-seven microfarads. When the distant end was put to earth through the wire of an electro-magnet, the resistance of which was 850 ohms, and an ordinary resistance coil of 1,600 ohms, the charge became neutralised by the induced electro-magnetic current, and consequently the discharge was *nil.* But by removing the keeper from the magnet, or varying the resistance of the resistance coil, the true or false discharge predominated. From the results of these and similar experiments, I was under the impression that by a judicious distribution of electro-magnets on subterranean lines greater speed might be obtained."

THE PHYSICAL SOCIETY.

This society commenced its winter session on Saturday afternoon, the 8th inst., Prof. Adams in the chair, when several electrical subjects were discussed. The first paper was read by Mr. W. C. Roberts, F.R.S., on an analogy between the conductivity of heat and the induction balance effect of copper tin alloys. Following up the experiments described before the society last session, Mr. Roberts had examined certain alloys, chiefly of copper and tin, by the aid of Prof. Hughes's induction balance, with a view of ascertaining whether their inductive curve corresponded with the commonly-accepted heat curve as laid down by Calvert and Johnston; and, secondly, whether the inductive effects varied to the same extent and at the same points as when these alloys are tested for the transmission of both heat and electricity. Matthiessen's curve for electric conductivity, which exhibited a remarkable resemblance to that for heat conductivity, had been questioned because of the materials he employed. But his results were in the main confirmed by testing these materials in the induction balance. Mr. Roberts's leading experiments were repeated before the audience; and they showed, first, that very slight variation in the proportions of the alloys gave greatly different readings on the induction scale; and, secondly, that the falling and rising were at particular points, results which in both respects agreed with the table of Matthiessen, and supported therefore the identity of heat conductivity and electrical conductivity.

Dr. Lodge supplemented the above paper with the results of his tests of these alloys, specimens of which had been furnished him by Mr. Roberts for that purpose—with the Wheatstone Bridge for resistance. The readings in this case were higher and steeper than those obtained by Mr. Roberts, as, for example, especially between those for Sn Cu 3 and Sn Cu 4; but, on the whole, there was a general agreement.

Prof. Ayrton was of opinion that the inductive effects of metals placed in the induction balance should not, and indeed are not, *proportionate* to their resistance. This, however, although it would affect the comparative readings, did not, perhaps, impeach the broad conclusions to be drawn from the evidence of the induction balance. After some observations from Prof. Hughes and Mr. Roberts in reply,

Captain Armstrong described a simple and easily constructed standard cell which he had devised about two years ago, and which had shown no variation since then. A cell of this kind gave results very little short of the truth; and, if checked, when first constructed, by some recognised standard of E.M.F. it would be practically accurate and always reliable. Its use was suggested for persons who could not obtain a more carefully and expensively constructed appliance. The specimen shown consisted of a porcelain vessel divided by a non-porous partition—two distinct vessels would serve as well—one chamber containing a semi-saturated solution of zinc in which was fixed the zinc element, the other a similar solution of sulphate of copper and the copper element. Thus the cells are absolutely independent when not in use; but when required for use, connection is made between the two liquids by means of a piece of wet string. Prof. Foster commented upon the enormous resistance introduced by such an arrangement, and thought that the normal moisture on the sides of the vessel might serve as well—or as ill—as the wet string.

Dr. Guthrie then drew attention to a communication he had lately received from Prof. Pirani, of Melbourne, relating to the "incandescence of electrodes." That gentleman had observed that when using platinum and iron poles in dilute acid for electrolytic purposes, the iron became incandescent in the liquid. Dr. Guthrie had verified the experiment, and added several others which he now repeated. No doubt Prof. Pirani had by this time pursued the same line of investigation, and arrived at like results. Dr. Guthrie had therefore no idea of anticipating Pirani's further communication but owing to the delay that must otherwise take place he thought the Society should be put in possession of the latest known facts. He employed a power of 50 Grove's cells; and, with this, some interesting and beautiful effects were obtained. Dr. Guthrie showed that if the platinum is the last to be immersed in the liquid it is the platinum electrode, and not the iron, that becomes incandescent. Next, that the same effects are obtained when both electrodes are of platinum, or both of iron; that the incandescence takes place only upon the electrode put in last: that electrolysis is apparently delayed so long as the luminosity continues; and that the light—of a deep red colour—at the Anode soon dies out, whilst the bluish green light of the Kathode continues a long time. The experiments were made with dilute nitric acid as well as with dilute sulphuric acid, contained in ordinary glass beakers, into which the electrodes were dipped. It was noticed that when the electrode was of thin wire the whole of the immersed portion was enveloped in flame, when on the other hand a broad strip of metal was immersed merely the tip of it was rendered luminous, and that only at the moment of contact with the surface of the liquid.

No discussion took place. The chairman, in closing the proceedings, congratulated the society upon the interesting character of the opening meeting, and upon the reappearance among them of Prof. Foster.

REFLECTORS FOR EVERY DESCRIPTION OF ELECTRIC LIGHT.—Chappuis' Patents. 69, Fleet-street.—[ADVT.]

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THE ELECTRICIAN.

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FORECASTING THE COMMERCIAL SUCCESS OF SUBMARINE CABLES.

In an exhaustive paper on the "Statistics of Telegraphy," read in September, 1872, by Sir James Anderson, before the Statistical Society, and published in the Journal of that Society, the following paragraph occurs:—"It must be accepted as a feature of telegraphic correspondence that commerce gives at least 90 per cent. of all international telegrams where the countries are remote." The author had previously in the same paper described the efforts made, and the facilities given, in order to obtain messages of a social character. He said: "We employed boats to go on board every steamer at Gibraltar, Malta, Suez, and Aden, and it is on record as a matter of experience that we did not get two per cent. of social messages from all our efforts in the first direction named. . . . . . Nor did we by employing boats to visit ships with passengers voyaging to and from all parts of the East obtain six messages in the six months." Reference was also made to the efforts to obtain press messages—the company going far in the diminution of the ordinary rates to effect this object. Excepting, however, during times of war or great political agitation, the revenue from this source was small. It may be that in the seven years since this paper was written some little modification has taken place in the proportion between the various kinds of cable messages, but we think the broad principle still remains that the commercial success of a cable depends practically upon the business messages which pass to and fro along the wires. It will be found, too, that Mr. C. L. Madsen agrees with this view, for in his paper on "The Law of International Telegraph Traffic" he supports Sir James Anderson's theory, and says, "The fundamental idea, which finally led to the establishment of the law, rests upon the simple and well-known fact that by far the greater part of all international messages concern under normal circumstances, either directly or indirectly, the commercial traffic only—a fact that has been pointed out in an able statistical treatise by Sir James Anderson." Mr. Madsen again points out that distance forms a most important factor in the law of telegraphic traffic. Keeping in mind, then, these various causes which act and react upon telegraph work, and leaving for the moment out of consideration the difficulties which occur in the manufacture and laying of cables, it will be seen that the promoters of any new cable have by no means an easy task in estimating the possible receipts. Not only must a careful survey be made of the commercial transactions of the district, but the business must be analysed. Some of it will undoubtedly be of such a character as to have little or no influence on telegraphic work, whilst, on the other hand, cable communication will develop certain branches of trade. Mr. Madsen, in the paper previously alluded to, concludes that the number of international telegraphic messages is a product consisting of two factors, as shown by the formula, $T = \frac{1}{d}\left\{\sqrt{V.}\,N + N_1 + N_2\right\}$ where d is distance, V the value of trade expressed in pounds sterling, N the tonnage of vessels engaged in the direct trade between the two countries, N_1 and N_2 denoting the tonnage of the vessels belonging to each country respectively.

There is again the important question of tariff. A diminution of tariff does not mean an equivalent increase of messages, in fact the contrary is the case, for in every recorded instance we believe diminution of tariff has led to a diminution of revenue. There is, of course, one tariff better than all others for every case, but as yet no one has satisfactorily solved the problem or shown how this tariff can be ascertained. The efforts hitherto made in this direction lead to empirical results—results which, derived from one case, cannot be used in any estimation for another case. Hence responsible persons are compelled to adopt high tariffs at the opening of an entirely new line. When a line has been opened for some time, the data for arriving at a fairly correct estimation of what the tariff should be are obtainable, and we think, in the majority of cases, the managers of cable companies have shown the utmost willingness to adopt reasonable tariffs. In the case of competition, certain complications are introduced which result in making any attempt at estimating the value of a cable, or to forecast its success, a failure. The promoters of these competitive schemes must be credited with speculative rashness amounting almost to foolhardiness in attempting to foist such schemes upon the public. We have in mind one or two such attempts which brought about the ruin of many confiding shareholders. We take it that Mr. Madsen is correct when he says, "We are, therefore, no doubt right in the conclusion that the onward movement in the intensity of the traffic is not so much the effect of modifications of the tariffs as in a far higher degree the effect of the incessant improvements in the service itself, and of the constantly increasing safety and rapidity in the transmission of the messages." As a rule, the companies do not hesitate to adopt any decided improvement brought under their notice, hence no competitive scheme can be far in advance of existing companies on this point. When we consider, then, the difficulties besetting any estimation of the probable success of a new cable, and add the dangers arising from rash competition, we can realise to a small degree the responsibilities of those gentlemen who have acted as the pioneers in submarine telegraphy, and who have brought the companies to the successful position they enjoy.

The practical questions asked by business men are:—

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What is the outlay? What are the probable receipts per annum? And what is the life of a cable? The revenue of a successful company should be such as will enable the shareholders to receive a fair dividend, and provide a reserve fund so that a new cable may be provided for when the old cable is past repair. These data, we think, can be obtained with a fair approach to accuracy by a due consideration of the statistical and other information to which we have thus briefly referred.

CORRESPONDENCE.

QUADRUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the number of *The Electrician* for 20th September, 1879, there is an extract from the *Journal of the Telegraph* in which some of our improvements in quadruplex telegraphy are stated to have been anticipated by Mr. F. W. Jones. Although we are aware that our priority as inventors of the system in question is in no way affected by the unpublished experiments of Mr. Jones in the same direction, we beg to point out that he has not even anticipated us in the matter of experiments, as the description of our arrangement, so far as it is quoted by him, is equally applicable to an arrangement which was successfully worked on a circuit 206 miles in length, between Salem and Madras, on the 16th of April, 1875. The fact is, Mr. Jones has left out of the description of our arrangements a most important point, and one that is essential to the practical working of the system, the introduction of which converted what could only be looked upon as an interesting and successful experiment into a practical system. The point we refer to is thus described in our specification:—

"Both the contact points are fixed to the same carrier, and things are so arranged that when once the contact points have been individually adjusted, their further adjustment for ordinary changes in strength of the currents is made simultaneously by one and the same motion of the carrier."

So long as the relay tongues were adjusted by separate adjusting screws, the system was of little or no practical use, since when the relay got out of adjustment it was very difficult, if not impossible, to readjust it without stopping the working of the other instrument; but with our present arrangement the adjustment when once made for a given battery ratio is as simple as the adjustment of an ordinary Siemens' relay.—Yours, &c.,

November 5th, 1879. MUIRHEAD AND WINTER.

THE UNIT OF ELECTRICAL WORK.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his letter on "Edison's Electric Generator," printed in your last issue, M. E. Hospitalier gives the following formula for "work transformed in electricity," viz:—

$$W = 10 \frac{E^2}{R} \text{ meg-ergs.}$$

This formula is a perfectly accurate expression for mechanical work converted into electrical energy, or for the heat *plus* work produced by a current, *per second of time*. But work has never yet been transformed into electricity; nor has electricity ever been converted into work. Further, if we *suppose* that work is transformed into electricity, the latter does not vary as $\frac{E^2}{R}$ but as $\frac{E}{R}$; so that the formula cannot possibly represent work transformed into electricity. M. Hospitalier should therefore have written:—Work transformed into electrical energy is—

$$W = 10 \frac{E^2}{R} \text{ meg-ergs, per second.}$$

But the main object of my present communication is to point out that electricians who adopt the *ohm*, the *volt*, and the *weber* as units of resistance, electromotive "force," and quantity cannot consistently adopt the *erg* as their unit of electrical work. The former units are derived from the absolute electro-magnetic metre-gramme-second system of electrical measurement, and were selected for their practical convenience by a Committee appointed by the British Association for the Advancement of Science. They are generally termed, therefore, "B.A. units." The latter unit, the *erg*, belongs to the centimetre-gramme-second absolute system—that which is at the present time most generally adopted. But there happens to be a B.A. unit of work, based, like the other B.A. units, upon the metre-gramme-second system, and related to these other units in such manner that no numerical constant is required in order to express electrical work in terms of electromotive "force" and resistance, or electromotive "force" and current, or current and resistance. Thus we have:—

$$W = \frac{E^2}{R} = E\,I = I^2 R \textit{ B.A. units.}$$

From this it follows, since the equation of M. Hospitalier is quantitatively correct, that the B.A. unit of work, to which, in my class, I have given the name of *Joulad* (in honour of one of the greatest physicists of modern times), is equal to 10 meg-ergs. It is also expressed by

$$1 \text{ Weber} \times 1 \text{ Volt} = 10^{-2} \times 10^{5} = 10^{3} \textit{ metre-gramme-second} \text{ units;}$$

and it is equal to 101·926 gramme-metres, or ·7372 foot-pounds.

In the B.A. system, we have the equations:—

$R = \frac{E}{I}$, $E = I R$, $I = \frac{E}{R}$, &c., as well as $W = \frac{E^2}{R}$, without any numerical constant. I need not insist upon the point that it would be quite inadmissible to have recourse to another system of measurement which, necessarily, complicates the equation.

It may be of use to some of your readers to refer here to the communication under the heading "British Association Units of Measurement" which appears on p. 236 of your first volume.—Yours, &c,

DESMOND G. FITZGERALD.

ANSWERS TO CORRESPONDENTS.

F.—We have occasionally seen the key in question employed; but we have never heard any complaint of non-simultaneous action in the springs making and breaking contact. We should, however, be glad to hear of your simplified method of construction.

J. DERLIN.—The "multicarbon" cell in question has a negative element of large surface; which is practically a hollow cylinder of carbon, since it is composed of a number of longitudinal plates of gas-carbon held together by a ring of metal cast round them at one extremity. A porous pot passes within the ring, and is surrounded by the carbon plates. The exciting fluid in the carbon compartment is generally a mixture of crude chromic acid with sulphuric acid. The zinc (amalgamated) is immersed in dilute sulphuric acid.

SOCIETY OF TELEGRAPH ENGINEERS.

The first meeting of this society since the vacation was held on Wednesday, Nov. 12th, at the Institute of Civil Engineers, Great George-street.

After the formal business had been transacted, the President (Major CHAMPAIN, R.E.) rose and said: Since the last general meeting of the society, held in May, the International Telegraph Congress had met, and the delegates had been entertained at South Kensington by the society. He could tell the members from the best of all sources, that of the delegates themselves, that the guests were highly pleased with the entertainment. The expenses of that gathering were defrayed by private subscriptions from the members of the society, and, owing to the excellent arrangements of the committee of management, a considerable sum remained after all payments were made. This sum, about £200, had, with the consent of the donors, been used to pay certain expenses of binding connected with the Ronalds Library. It was well known to the members that the Ronalds Library was held by the society under certain conditions, one of which was that the pamphlets should be bound. The cost of this work was nearly £200, and by the arrangement just mentioned this had been met without trespassing on the funds of the society. He was pleased to inform them that the finances of the society were in a satisfactory state. Not long since a loan had been obtained to enable them to clear off debts, and to print the proceedings more economically. At the time this loan was obtained an agreement was made to repay it in seven yearly instalments, but they had been able to do more than this, for one-third of the total amount was already paid. The number of new members was satisfactory. Since the May meeting the society had to regret the loss of one of its honorary members, the late W. Fothergill Cooke. The name suggested a celebrated pioneer among telegraph engineers, and a memoir of the late Mr. Cooke would be published in the forthcoming number of the *Journal*. The secretary would now read a paper by Mr. J. R. Preece, on "The Telegraph from Teheran to Bushire." At the commence-

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ment of this paper reference was made to contributions appearing in vols. xiii. and xiv. of the Society's *Journal*, upon a similar subject. The author then briefly described the history of Persian telegraphs, speaking of the many and great difficulties which had to be overcome by the energy and tact of the officers who in the first instance had charge of the work. The greatest difficulties were, perhaps, those caused by the Persian Government. However, at length the line was erected, and on the 13th October, 1864, Major Champain was able to report the completion of 1,100 miles of line. Political and other considerations led to the erection of an alternative line, and eventually to a third line. When only one wire was in existence, the *employés* of the Persian and English Governments took possession and worked alternately, but as this led to difficulties the second line was made, Persia having charge of one, England of the other. The negotiations for this line were carried out by Colonel Goldsmid. A brief topographical description of the country through which the telegraph from Teheran to Bushire runs was given, a fuller description being prepared for insertion in the *Journal*. The wire used for the first line was of the size known as No. 5 B.W.G., partly supported by wooden, and partly by iron poles of Siemens' and Hamilton's type. The wooden poles, being subject to the ravages of the white ant, have been replaced by iron poles, principally of the Siemens type. On the plain these poles are 80 yards apart, on the hills they are placed as wanted, and they are of two kinds, "strainers," and those known as "intermediate." The author described the furniture of the poles, the staff employed to keep the line in repair, and the daily testing. The latter, for example, takes place regularly at nine o'clock, and a record is kept of the daily conductivity and insulation of the wire. As might be supposed, these vary considerably during the dry and rainy seasons, and in sections like that near Bushire, which is over a marshy tract. Various tables were given in the paper, which will appear in the *Journal* of the society.

The interruptions and their causes were then noted, and as an example of what difficulties the officers have to contend against we may cite the amusement of shooting at the poles. This favourite amusement of the villagers is now on the decrease, as will be seen from the following table :—

In 1874-5	217	poles were bulleted
In 1875-6	88	,, ,,
In 1876-7	45	,, ,,
In 1877-8	25	,, ,,
In 1878-9	21	,, ,,

Another difficulty experienced was the cracking of the standards where the pole enters the socket.

In order to obviate the bad insulation due to wet or foggy weather, to spiders webs, &c., it was stated that an experiment was to be made with the insulators of Messrs. Johnson and Phillips, a number of which were now being sent out.

The double current system has been generally adopted, and works well except at Bushire, where it was given up, and a modification established. Earth currents rarely affect working. The battery used is a modification of Minotti's.

A singular fact was mentioned with regard to duplex. In 1872-3 M. Fahie, assistant superintendant, devised a system founded on Mance's well-known testing method, wrote a full account of the invention, and sent it to England. The MSS. was unfortunately lost, and the delay enabled other discoverers to devise systems and claim priority.

The President opened the discussion, and as he had had a good deal to do with the line from its first conception till the present time, he was able to interest the audience. He said that when a line was first proposed to connect England with India, the Red Sea route was chosen, but the cable failed. Then a scheme to erect a line to give the connecting links from Bagdad to Bussorah was suggested, but owing to difficulties likely to be met with in this case, the alternative route through Persia seemed better. Eventually both connections were made, and the difficulties proved less than had been anticipated.

The energy of the Eastern Telegraph Company proved the soundness of their convictions as to the ability to establish communication *viâ* the Red Sea, and the rival lines were opened about the same time.

Mr. C. F. Varley discussed the question of failure of the original Red Sea cable. It was not because of rocks, but from defect of knowledge. The cable was taken out dry, and badly covered with iron sheathing; in laying, 106 miles were stretched to 107, and it was from causes of this character, and not from rocky bottoms, that the cable failed.

Mr. Latimer Clark suggested that the cracking of the sockets might be due to the expansion of the cement used; and after a few other remarks he proposed a vote of thanks to the author of the paper, remarking that one of the great features of the society was that its members in far off lands could contribute their experience to its proceedings.

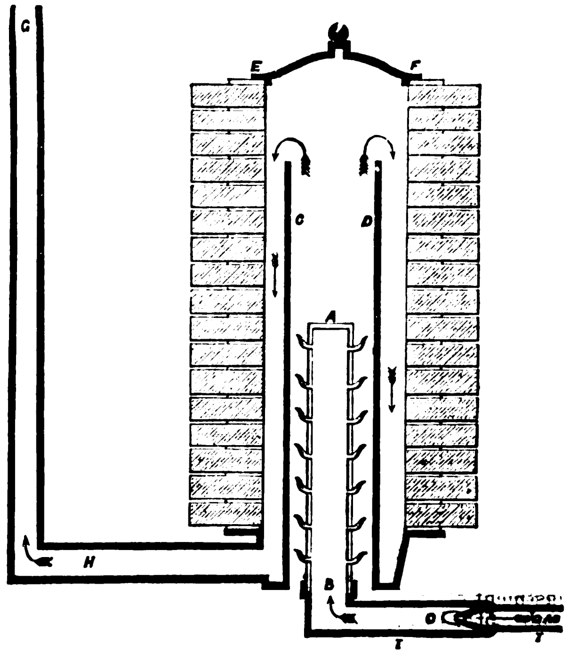
LITERATURE.

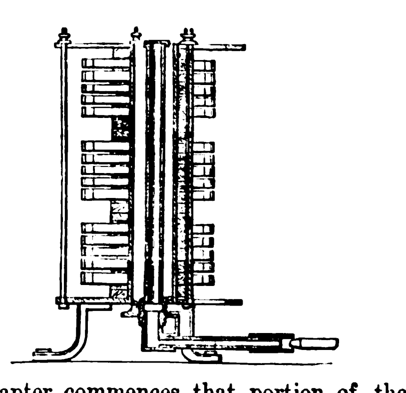
The Students' Text-Book of Electricity. By H. M. Noad, F.R.S. New Edition. Carefully revised, with an Introduction and Additional Chapters. By W. H. Preece, M.I.C.E. [London: Crosby Lockwood and Co.]

Third Notice.

Notwithstanding the adverse criticisms we have been compelled to make upon the method and matter of the earlier portion of this book, we are compelled to acknowledge that the latter part is most valuable, as containing graphic descriptions of the principal apparatus used in the electrical world. In chapter XVI., thermo-electricity is discussed. We are of opinion that the progress made in thermo-electricity has not been so patent as in other branches of electrical science, and although much work has been performed, we should not be surprised to hear of startling strides in this direction. At the present time the batteries of Clamond and Wray take the lead, and these are described and illustrated.

The accompanying figures, for which we are indebted to Messrs. Crosby Lockwood and Co., show sections respectively of the Clamond and Wray thermo-piles, and form good examples of the illustrations that are to be found throughout this work.





The next chapter commences that portion of the work devoted to the consideration of the application of electricity to telegraphy, and here Mr. Preece is dealing with matters to him "familiar as household words." It will surprise no one, therefore, to find the history of telegraphy treated in a compendious and reliable form, whilst the apparatus in everyday use is clearly explained. On pages 448-9-50 the question of the earth-circuit is discussed, but as it seems to us without giving much assistance to the student. Several theories are mentioned, and the paragraph concludes with "Matteucci's views are those which are generally adopted." The author, however, carefully abstains from giving an opinion as to why Matteucci's theory should have the preference over Gavarret's or any other theory. In that portion devoted to submarine work, some of the recent improvements in grapnels might with advantage have been described, and while speaking of Siemens as proposing, it might be stated that the Telegraph Construction and Maintenance Company

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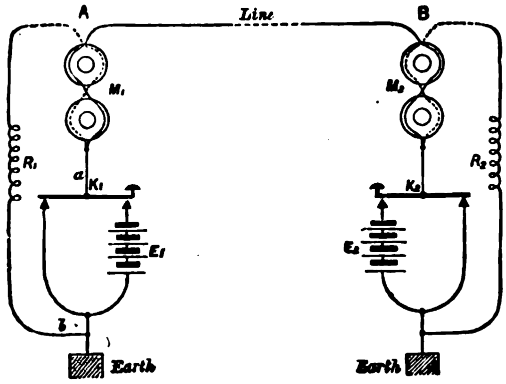
carried out, the covering of cables with metallic tape to prevent their destruction by the teredo and other marine insects. Chapter XIX. is devoted to duplex and quadruplex telegraphy. As an example of the method of treatment of this portion of the work, we extract the description of duplex work :—

"Like all other systems, the duplex method of transmission has been effected in various ways, and has been applied to various kinds of apparatus. As most of these are in but very limited use, two only, which are now very generally employed by all telegraph administrations throughout the world, will be described, viz., the "differential" and the "bridge" duplex systems, applied to the Morse instrument. The figure shows the former of these methods—viz., the "differential" method—which is, in fact, the one originally invented by Frischen.



"M_1 and M_2 are the electro-magnets of the receiving instruments at the stations A and B. These electro-magnets are each wound with two wires of equal length and diameter, and consequently of equal resistance.

"An electro-magnet so wound can be excited, and caused to work the instrument, of which it forms a part, if—

"1. Currents pass through either of the coils in either direction.

"2. Currents pass through each coil in the same direction, the strength of the current in one coil being either equal or unequal to that in the other.

"3. Currents pass through each coil in opposite directions, the currents in one coil being greater than that in the other.

"If, however, currents pass through each coil in opposite directions, the current in one coil being equal to that in the other, then no effect will be produced.

"In what way can these conditions be applied so as to effect duplex transmission?

"Suppose the key K_1 at station A to be depressed, then a current will flow from the battery E_1, a portion going through one coil of M_1, and through a resistance R_1, to earth; the other portion of the current will go through the other coil of M_1, and out to line. As the connections are so made on to M_1 that the currents through the coils flow in opposite directions, and as R_1 is adjusted so that these currents are equal, the electro-magnet M_1 is unaffected.

"The portion of current flowing out to line passes through that coil of M_2 to which the line is connected, and thence goes to earth through the back stop of the key H_2; M_2 being then under the conditions specified in 1 consequently responds.

"If B were the transmitting station, then it is evident that M_1 would respond, but not M_2. Now, suppose that both keys are depressed; in this case, as the two similar poles of the batteries are connected to one another, no currents can pass through either of those coils of the electro-magnets which are connected to the line; currents, however, flow through each of the other coils, and both instruments consequently respond.

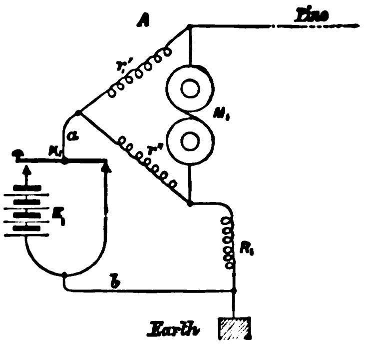
"There is still another condition of the keys to consider, and that is, when one key being down the second commences to be depressed, and leaves its back stop without touching the front stop. In this case, at the station where the second key is placed, the current, instead of passing to earth through one coil of the instrument, passes through both coils and gets to earth through the balancing resistance; but, as it passes through the coils in the *same* direction, the condition of affairs is that stated in 2. The instrument, therefore, still remains affected.

"At the other station the current flowing through the coil of the electro-magnet connected to the line becomes reduced in strength, in consequence of its having to pass through a greater resistance than was the case at first. The condition of affairs in this case is that stated in 3; consequently the instrument at this station commences to respond; when the key has become quite depressed, we get the condition that has been before discussed.

"It will easily be understood than an essential element of success in the system lies in the adjustment of the resistances R_1 and R_2; it is necessary that this adjustment should be such that the currents passing through the two coils of the electro-magnet at one station, when that station alone is transmitting, are equal. As the resistance of the line is subject to continual alteration from climate influences, the resistances R_1 and R_2 are made adjustable, so that balance can always be preserved.

"In the figure and description it has been assumed that the batteries E_1 and E_2 are so arranged that when the two keys are depressed similar poles are connected together, and no current passes out to line. This arrangement of the batteries is not, however, essential to the working of the system, as it will work equally well with one of the batteries reversed, so that when the two keys are depressed similar poles are connected together, and no current passes out to line. This arrangement of the batteries is not, however, essential to the working of the system, as it will work equally well with one of the batteries reversed, so that when the two keys are depressed the opposite poles of the batteries become connected. In this case, instead of there being at each station a current passing through one coil of the magnet only, there will be an equivalent effect produced by twice as much current passing through one coil as through the other; the working of the apparatus will therefore be exactly the same in the two cases.

"The 'bridge' duplex system is shown by the figure, one station, A, only being represented.



"In this arrangement the instruments do not require to be double wound, a balance being obtained by the adjustment of three resistances, r_1', r'', and R_1. To obtain this balance the relative values of these resistances must be such that

$$r_1' : r'' :: L : R_1,$$

L being the resistance of the line plus the resistances at the further station, B. A like proportion is also given to the resistances at B.

"Practically, in order to allow for variations in the resistance of the line from climatic changes, it is sufficient to adjust the resistance R, and the corresponding resistance at station B, the other branch resistances remaining unaltered.

"It is unnecessary to consider the way in which the movements of the keys control the currents in the foregoing arrangement, as it is substantially the same as in the differential method. In describing the differential duplex it was pointed out that if K_2 was down, K_1 being up, then the course of the current was such as to work M_1, and if K was then depressed, sufficiently only to disconnect it from its back stop without making contact with its front stop, the course of the currents would still be such as to keep M_1 affected. The effect on the magnet in the two cases is, however, unequal, and this tends to make the signals received on the instruments somewhat irregular, though, as a rule, not sufficiently so as to interfere with the working. In order to remedy this defect the transmitting keys are sometimes so arranged that contact is not broken from one stop until contact is made with the other stop. Such a device is shown by Fig. 442. In this arrangement *l* is a short lever, which normally rests on a contact connected to earth and one pole of the battery. The lever of the key itself is connected to the second pole of the battery. On depressing K, it first makes contact against the lever *l*, and then disconnects the latter from the stop against which it normally rests."

The work concludes with chapters on the Electric Light, and on "Miscellaneous Applications of Electricity," subjects requiring a much greater space for adequate discussion than is given to them. The concluding paragraph admits this fact, and we think, should another edition ever be undertaken upon the same plan as the present one, it would be advisable to leave out altogether much of this miscellaneous matter, and deal at greater length with some other portions of the subject.

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UNIPOLAR INDUCTION, ATMOSPHERIC ELECTRICITY, AND THE AURORA BOREALIS.*

BY E. EDLUND.

(Annales de Chimie et de Physique, vol. xvi., pp. 49-107; and Kongl. Svenska Vetenkaps-Akademiens Handlingar, vol. xvi., p. 1.)

Let a steel magnet be arranged in a vertical position, readily set in rotation about its geometric axis, and surrounded by a metallic muff in the form of a cylinder, also capable of turning about the same axis. The current from a battery being caused to pass into this cylinder, so that one of the electrodes is in contact with the cylinder near the poles of the magnet, and the second electrode at a point between the two poles, the cylinder will begin to rotate about the magnet. The direction of rotation depends on that of the current in the cylinder, and on the situation of the poles. The magnet itself remains perfectly motionless, consequently the current does not exert upon it any rotary action. It is therefore possible to turn the magnet mechanically around its axis without the slightest resistance being offered by the reciprocal action of the magnet and current. The author has previously shown† that, according to the mechanical theory of heat, every like phenomenon will be accompanied by phenomena of unipolar induction. If the battery is removed, and replaced by a galvanometer, the latter will indicate a current as soon as the cylinder is mechanically put in motion. This kind of induction has been termed unipolar induction. The current produced is proportional to the velocity of the cylinder. The simultaneous mechanical rotation of the magnet produces no increase in the current generated by rotation of the cylinder. Plücker has proved experimentally that in this case the rotation of the magnet is incapable of producing a current. For the magnet a solenoid can be substituted, producing the same effect.‡ Edlund has shown that the rotation of a solenoid about its axis cannot produce a unipolar induction current. It is, therefore, the rotation of the cylinder about the magnet that gives rise to the unipolar induced current; while the rotation of the magnet about its axis has nothing to do with the phenomenon. If the magnet and cylinder are connected together, so as to form a compact body, the magnet is carried in the direction of the rotation of the cylinder, without any modification in the induction of the magnet. The magnet acts in this case on the cylinder as if the former were immovable and the latter rotating. That the magnet cannot produce unipolar induction, in a conductor with which it is intimately united, is therefore not correct. If the radius of the cylinder be sufficiently reduced for the cylinder to be in perfect contact with the magnet, this circumstance will not prevent induction occurring in the cylinder; and because this induction will be produced irrespective of the thickness of the cylinder, the latter can be entirely removed, and the terminals of the galvanometer put into immediate contact with the magnet, without causing the induction to cease. The magnet, then, performs the functions of a conductor, and the induction does not result from its being put in rotation as a magnet, but as a conductor. This unipolar induction was first studied by W. Weber.§ The induction at any point of the conductor depends upon its motion relatively to the magnet regarded as a fixed point. As is known, this relative motion undergoes no modification if to the magnet as well as to the point in question equal velocities in the same direction be imparted.

Unipolar induction ought not to be considered a real induction, but an ordinary electro-dynamic phenomenon, due to the action of the magnet upon the electric currents produced by the rotative motion of the conductor. As for the action of the magnet, whether the currents on which it acts are produced by particular electromotive forces, or by the electric fluid being conveyed in the direction of motion of the conductor, is immaterial. If unipolar phenomena are regarded as belonging to those of induction, it is necessary to distinguish the following kinds of magnetic induction :—(1). Induction due to the action of the magnet upon the induced circuit augmenting or diminishing, or undergoing variation. This may occur either by the magnetic moment undergoing a change, while the induced circuit and the magnet remain at rest, and consequently do not alter their relative position; or the magnet and the induced circuit approach towards or recede from each other without the magnetic moment undergoing variation. (2). Induction due to the circumstance that the conductor moves, in regard to the magnet, without the distance from the poles of the latter to the different points of the conductor necessarily varying, and without increase or diminution of the magnetic moment; and this is unipolar induction. These different kinds of induction may be present in combination.

In a second part of the paper the Author treats of atmospheric electricity and the aurora borealis. The earth may be considered as a relatively good conductor of electricity, and the atmosphere as a bad conductor. Its conductivity, which depends almost exclusively upon the amount of humidity, is subject to incessant variation. As the density of the air diminishes, its conductivity increases, and there should consequently exist, at a considerable height, a stratum of air of moderate conductivity. The surface of the earth is immediately surrounded by a stratum of air of low conductivity, subject to incessant variation, and to this layer succeeds another, of which the conductivity is greater, and sensibly invariable. The magnetic action of the earth cannot be entirely explained as due to a magnetic mass, making a certain angle with the plane of rotation, for the magnetic action is too irregular; but the idea is sufficiently correct. The magnetism of the earth may be considered as acting upon an element of current situated in the atmosphere, with a force capable of being resolved into components, that in the direction of the dipping-needle being zero. In equatorial regions, or in low latitudes, the force of terrestrial magnet induction is very intense, and renders the atmosphere electro-positive; the resistance to discharge is also great. When the vapour of water in the air condenses to form clouds, these become charged with electric fluid. The cloud, which is a good conductor, is thus charged with positive electricity. Clouds negatively charged by induction from the positively-charged clouds, are also formed. If the charges are sufficiently intense, the clouds may become discharged to earth instantaneously in low latitudes, but in higher latitudes, where the resistance of the air is less, these discharges are transformed into slow and continuous currents, giving rise to the phenomenon known as the aurora borealis. The annual period of frequency of this phenomenon is due to the electricity accumulated in the atmosphere by the unipolar induction of the terrestrial magnet, and this descending to the earth either as a storm of great intensity or as a slow and continuous discharge, gives the phenomena of storms at the equator and of the aurora at the poles. The consequences of this theory are examined at length, and the author shows that unipolar induction plays too important and significant a part in these phenomena to be neglected in their consideration.

* Transactions, Institute Civil Engineers.

† Wiedemann's Annalen, vol. ii., p. 347. ‡ Pogg. Ann. vol. clx., p. 604. § *Ibid.* vol. lii. p. 353.

THE IMPROVEMENTS SCIENCE CAN EFFECT IN OUR TRADES AND IN THE CONDITION OF OUR WORKMEN.*

BY PROFESSOR W. E. AYRTON.

(CONCLUDED FROM PAGE 300.)

I have said that the main object of education is the mental training which it ensures, and, as a proof of how very much more important this is than any mere accumulation of facts, may be seen from so many inventions having been made by minds which, although educated, had but a small knowledge of the special details of the science to which the invention belonged. Take, for example, the Bell's telephone; it was not any very extensive acquaintance with electrical apparatus that enabled Prof. Bell to invent this apparatus. Nor, again, was it a wide knowledge of the laws of acoustics that led Mr. Edison to successfully devise the first practical talking machine, the phonograph. And, thirdly, it was not any special knowledge of telegraphy that led Mr. Cowper to invent his "writing telegraph," and similarly with several other discoveries.

We may say that the invention of the Bell's telephone depended on the inventor, during his investigations of the experimental methods of determining the natural pitch of vowel sounds, seeing that magneto-electricity (that is, the generation of an electric current by the motion of a magnet near a coil of wire) realised, as Sir William Thomson puts its, "the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously, and, as nearly as may be, in simple proportion to the velocity of a particle of air engaged in constituting the sound."

Magneto-electricity, as you no doubt all know, was discovered by Faraday, and is one of the most beautiful examples of the importance of studying elementary principles. Faraday was not a student at a university, spending money and time in learning the conventional accomplishments of a gentleman, but he was the son of a blacksmith who had, by hard work, to earn his own living. I have no time now, I wish I had, to tell you about the life of that one of England's heroes who spent it in fighting against and vanquishing scientific difficulties in order that the world might add to its possessions a new and unknown land of scientific discoveries. But I will say just one word about this discovery of magneto-electricity, since on it depends all the electric lighting of the present day, and all the electric transmission of power—that vital question of the future.

Faraday knew that motion could produce electricity with the ordinary glass electrical machine, and that the electricity so produced could in its turn set up motion, as in the pith ball telegraph worked by Sir Francis Ronalds. He knew that difference of temperature could produce an electric

* Inaugural Lecture at Cowper-street Schools in connection with "The City Guilds Institute."

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current, and the electric current could in its turn produce heat or difference of temperature. Consequently, Faraday felt sure that since an electric current can, as you have seen, produce a magnet, a magnet must in some way be able to create an electric current. But his attempts were baffled time after time; failure, failure only, was the result; yet, buoyed up with hope, still persevering with that dogged earnestness which is the characteristic of an Englishman, he at length arrived at this all-important discovery—to produce a current with a magnet, it is no use placing the magnet this way or that way relatively to the coil, but you must have *motion* of the one relatively to the other.

Here we have a vertical copper wire, up or down which we can send an electric currrent, produced by a battery outside the room. Behind the wire there is a magnet, suspended on a horizontal axis, so that it can turn in a vertical plane. The magnet is so arranged that usually it stands upright, but if I send a current upwards you observe this end turns to your left, while if I reverse the direction of the current the same end now turns to your right, the magnet in both cases placing itself at right angles to the wire.

Such an arrangement, then, is a detector of a current, but it is rather a rough one, and only indicates the presence and direction of large currents. But this other instrument, in which the wire goes many times round the suspended needle, is more sensitive, and as the deflection of the magnet is indicated by the motion of a beam of light reflected from a small piece of looking glass stuck on the magnet, the presence of very small currents may be detected. To the two ends of the wire forming the current-detector are attached the two ends of the wire forming this coil. The spot of light is now in the centre of the scale, indicating the magnet is undeflected, or that no electric current is passing; but if I rapidly move towards the coil this magnet which I hold in my hand, the spot of light is deflected to the left, and then comes back to the zero position, indicating that an instantaneous electric current was set up in one direction. Now, if I rapidly remove the magnet I have in my hand, you observe that the spot of light swings to the right and then comes back to zero, indicating an instantaneous electric current in the opposite direction.

When Faraday first made this discovery in 1831, I have no doubt many people thought it a very pretty scientific experiment, but not likely to be of any practical use. Yet to what a host of practical purposes has it been applied during the last forty years. We now see that the invention of the galvanic battery, such as we are using for producing the electric light in this hall, is beginning to sink in importance before magneto-electric induction; for how do we get those strong currents to produce the electric lights of the present day on the Thames Embankment, the British Museum, or nearer still, in Aldersgate Station? By magneto-electric induction. How do we get these sparks with this Ruhmkoff's coil which enables us to imitate lightning on a small scale, and so to devise by experiment lightning protectors for our telegraph lines? By magneto-electric induction. Magneto-electric induction is used not only in the Bell's telephone (one of which you now hear on this table giving out the ticking of that clock by the aid of Hughes's microphone, and another of which you see employed with this Hughes induction balance, by means of which two grains of gold can be detected in a pound of silver, solely by the slight electrical change so small an admixture of gold produces throughout the whole mass), not only I say is Faraday's principle of magneto-electric induction employed in all these wonders, but it is made use of in Edison's loud-speaking telephone which you now all hear telling you the words spoken to it by a man in a house in Tabernacle-road.

But, besides magneto-electric induction, Mr. Edison employs two other most ingenious principles in order to fulfil the necessary condition of every instrument used for electrically transmitting human speech, viz., that the strength of the electric current must be nearly proportional to the velocity of the particle of air engaged in constituting the sound. The first of these principles, discovered by him in 1872, is, that the passage of electricity, from one body to another resting on it, diminishes, in certain cases, the friction between them, and allows slipping to take place more easily if they are pulled one over the other. For example, if I am pressing a piece of platinum attached to the zinc pole of a battery, as in the figure, on to a piece of paper moistened with a dilute solution of hydrogen disodic phosphate, and attached to the copper pole of the battery, then if a pulling force be applied to the paper, a little less than that necessary to make it slip, it will be found that slipping will take place whenever the key is pressed down, so that the electric current is allowed to flow, and the paper will stop again each time the circuit is broken, so that the current is stopped. Already this principle has enabled Mr. Edison to convert his motograph or telegraph receiving instrument without electro-magnets, and, it may possibly be found to have some connection with the comparative inefficiency of railway brakes when skidding takes place, that is when the rotation of the wheels is entirely stopped. But most important of all, Mr. Edison, by means of it, was enabled to devise his "loud speaking telephone," when the Bell Telephone Company would not allow him to make use of theirs. Inside this instrument there is a cylinder of compressed chalk, A in figure, moistened with the liquid I have already referred to. C is pressed on to the chalk cylinder, so that when the chalk cylinder is rotated, C is, by friction, pulled a little onwards, and the diaphragm is stretched. If, now, an electric current, coming from the distant station, passes from the strip, C, to the revolving chalk cylinder, A, the friction is lessened, and the diaphragm springs back, and thus swingings of the diaphragm are set up exactly in time with the alterations in the strength of the electric current. But how does Mr. Edison make these variations of strength of the current time with the sound waves emitted from the speaker's mouth? By utilising another very pretty principle—that carbon opposes less resistance to the passage of an electric current, becomes, so to say, more porous to electricity, if you squeeze it. A galvanic battery sends a current through a piece of pressed carbon at the speaking end, and the sound waves emitted by the speaker's voice strike this carbon, and press it, more or less, making the current stronger or weaker.

Next, let me draw your attention to the American Stock Printing Telegraph, of which we have specimens in this hall receiving and printing messages sent from a house in Tabernacle-road. This instrument, in that the paper is started running, the message is printed, and the paper stopped again when the message is finished, all by electric currents coming from the distant station, and without any control of any kind at the receiving end, may be looked upon as wonderful, even for an American invention.

Look again at Cowper's writing telegraph, some specimens of the production of which are now handed round the room. It is a well-known principle that any motion along a plane may be regarded as the result of two motions at right angles to one another; any motion of a fly, for example, crawling along a wall, is so much movement up or down, combined with so much movement sideways. With these two levers working at right angles to one another, and conjointly moving a pencil, I can write what I like, or, if properly controlled for me by these cams, they will write definite letters in this case, "W. T."—Mr. Cowper's initials. This idea is employed in defining the position of a place on the earth's surface by its latitude and longitude, it constitutes the whole of the science called *analytical geometry*, which has been of such service in all branches of modern scientific advance. And yet it does not seem to have occurred to telegraph engineers that all ordinary writing can be compounded of two motions at right angles to the two edges of the paper, and, by well-known electric principles, can be exactly reproduced and compounded at a distance, producing a fac simile at one end of the line of what simultaneously is written at the other. Technical education being what it is, it is not surprising that this electrical invention should have been made by a mechanical engineer and not by an electrician.

We might, did time only allow, go on multiplying indefinitely examples to prove that a *general* knowledge of elementary principles is of the greatest importance to every man, whatever be his trade. George Stephenson, but a coal miner, and yet the practical inventor of the present locomotive engine, understood that fully. No institute for the advancement of technical education was founded for him, no City companies lent him a helping hand, and yet he set himself to study the principles of mechanics when he had only just succeeded, with great difficulty, from his absence of leisure and instruction, in teaching himself to read and write, as he sat by the engine fire. The account of his experiments to discover a form of miner's safety lamp is a living exemplification of the rule attributed to Bacon, but, in reality, given long before by the painter Leonardo da Vinci:—"Begin with observations, go on with experiments, and, supported by both, try to find a law and a cause." Starting with his own idea that, in order to prevent fire-damp exploding, it was necessary that the gas should pass through the lamp at a certain velocity, Stephenson arrived, after many experiments, at the all-important result, discovered quite independently by Sir Humphrey Davy, that wire gauze, if the meshes are of sufficient fineness, cuts, as you see, a mass of gas into two portions, one of which can be ignited without the other catching fire or exploding.

And, realising so fully as he did the advantages of education, it is not to be wondered at that he strained every nerve to have his son Robert well taught, and even sent him to the Edinburgh University, where, in six months, he is said to have acquired as much knowledge as takes many ordinary students three years to learn. And why to Edinburgh University, and not to some nearer English college? Because, at that time, there was no institution where the means of a man like George Stephenson, only one step removed in position from that of an ordinary miner, could obtain even a decent scientific education.

And what has been the result of this cheap and general Scotch education spread over many years? Why, that we now see so many posts at home and abroad held by Scotchmen, just as we find a considerable portion of the more important positions in our manufactures occupied by young Germans solely on account of the scientific training they have received.

What were the feelings Professor Bell had when in England? He wrote to America:—"If you want to know why inventors are more numerous in America than they are in England, come and live for six months in England. If you wish to know what it is to be brimful of ideas, and yet to be unable to have them executed, come to England. Masters, instead of encouraging invention, do all they can to put a stop to it, by charging the most exorbitant prices for experimental work, avowedly because they don't want such kind of work because it gives, they say, more trouble than it is worth," and much more of the same nature.

Now granted, if you like, that this is much exaggerated, granted, even if you wish, that it arose from national prejudice, still we must remember that Bell himself was an Englishman, and the inventor of one of the most wonderful instruments of modern times. Also we must not forget that George Stephenson's attempt to survey the route for the Liverpool and Lancashire Railway led to his being frequently stoned by the inhabitants of the property, who have since most largely benefited from his work; and that Sir Francis Ronald's letter to the Secretary of the English Admiralty in 1816, describing the electric telegraph that Sir Francis had constructed, and successfully worked, led to an answer, splendidly calculated to foster invention, viz:—"Mr. Barrow presents his compliments to Mr. Ronalds, and acquaints him, with reference to his note of the 3rd instant, that telegraphs of any kind are wholly unnecessary, and that no other than the one now in use" (that is the semaphore) "will be adopted."

If England is, then, so lamentably deficient in technical education, how is it that English engineers and English workmen have hitherto been considered first in the world? Because we started earliest in the race, because we had an abundant supply of coal and iron, and, lastly because we had indomitable energy; but Dr. Lyon Playfair, some years ago, asked this question, and the present depression in trade leads me to ask it again now:—"Do you sincerely think that the country can continue in a career of prosperity, when she is the only leading State in Europe that is neglecting the higher education of the working classes, and of those men above them whose duty it is to superintend their labour? It is a truth incapable of being gainsayed, that science must be joined to practice in the advancing competition of the world, in order that a nation may retain the strength and energy of manhood; for States, like individuals, fall into decrepitude and decay." Dr. Lyon Playfair has been answered; answered sooner, and in a more decided manner, than even he could have feared; and that reply is, No! our country has, indeed, not continued in its former state of prosperity. Years ago France, Germany, and, above all, Switzerland, set themselves the same question, but instead of waiting, like ourselves, for time to give the sad response, they foresaw it, and, by fostering technical education, have absorbed into their country some of the industries of the world. The city and canton of Zurich, having once grasped that their system of national education was defective in modern practical science, vied with each other in providing funds for the complete equipment and support of a technical university. They did not, as Mr. Scot Russell tells us, ask themselves "what is the smallest and least costly scale on which we can begin to make good a few technical deficiencies?" but they asked themselves that other

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question, "what is there in the science, the philosophy, the learning, the art, and the practical skill of modern times, which can be learnt and taught, but for which there is no adequate provision already made for teaching to our students in the universities of our land."

And yet another nation, small and apart from the world, a people like the Swiss, dwelling in a mountainous country, and like them too dearly loving their pine-clad hills—the Japanese—have set us an example that our ambition should lead us to emulate. Much have we heard of Japanese art, much have we seen of Japanese lacquer, Japanese fans, but only a few of us are acquainted with the Japanese modern technical education. Ten years ago a feudal country, tyranised over by barons, with power of life and death in their hands, distracted by the conflict between the rightful sovereign and their hereditary military usurper, that nation whom we regarded as barbarous, that nation of whose manners we were comparatively ignorant, whose very modes of thought are so different from our own that we can hardly be said to understand them now, that people had but three years emerged from a state of almost slavery, when up grew, in its very midst, a technical college, with its staff of carefully-chosen English professors, with its laboratories, its class-rooms, museums, libraries, and workshops, costing Japan, a poor country be it remembered, at least twelve thousand pounds a year to support, and many many thousands to build. And to enter and study at this college, neither money, nor position, nor any qualification is necessary but ability and desire to study; so that working at the lathe, or conning over their books in the class-room, or experimenting in the laboratory, may now be seen, side by side, the young noble and the young artisan.

An example to emulate, did I say? The City companies have given us the opportunity, let us show that we appreciate it. They do not propose merely to teach each man his trade or business, for that he can best learn in the workshop or counting house; nor have they any idea of merely grounding you in elementary arithmetic, since that you can learn at school. They do not start by building handsome edifices, although they have already subscribed many thousands for erecting in London a large central technical college; but what they have done is henceforth to put on one side more than fifteen thousand a year of their own money to give you from now that education which will enable you to commence doing what George Stephenson, in these words, half a century ago, urged on you:—"Learn for yourselves, think for yourselves, make yourselves masters of principles, persevere, be industrious, and then there will be no fear for you."

In responding to the vote of thanks that had been given to the lecturer, Professor Ayrton asked the audience to award another and a larger vote of thanks to Messrs. Siemens, Mr. Preece, Mr. Arnold White, secretary of the Edison Telephone Company, Mr. Davies, manager of the Exchange Telegraph Company, Mr. Cowper, Mr. Conrad Cooke, Mr. Apps, and Mr. Grooves, for so courteously lending the apparatus that had contributed so much to the success of the lecture.

RECENT PATENTS.

801. Auto-Quinetic Telegraph Apparatus, *L. M. de B. y O'Lawlor. Dated 27th February*, 1879.—*(Not proceeded with)*. 4*d*.

A single line wire runs in succession through all the apparatuses in the houses on the line, being connected auto-quinetically therewith, that is, in such a manner that when any one of the latter is set so as to send a message to the station, the continuity of the line is broken at that apparatus.

806. Telephones, *J. Imray.—Dated 28th February*, 1879.—*(A communication).—(Not proceeded with)*. 2*d*.

An electric current undulating in a coil enclosing a bar of magnetic material produces molecular vibrations in the coil, and also in the bar. These vibrations are rendered appreciable as pulses of sound either by leaving the coils free among themselves or making the bar very small, or subject to a constant strain.

827. Duplex Telegraphy, &c., *R. Theiler and M. Theiler.—Dated 1st, March*, 1879. 6*d*.

The contact arm of an ordinary polarised relay (connected with a Morse or sounder) and the lever of the sending key are connected and work together in such a manner that when signals in opposite directions are transmitted simultaneously, and the line current is therefore neutralised, preventing the receiving of such signals, the contact arm of the said relay is moved against the marking stop mechanically, and the signal of the sending station is in that case recorded mechanically by the receiving station. But as soon as the neutralisation of the line current ceases, that is when one of the two keys falls back upon its rest stop, the key which is still sending into line is prevented by suitable means from moving the relay arm of its own station and works the relay of the further (receiving) station only.

830. Electric Lamps, *G. G. André.—Dated 1st March*, 1879. 8*d*.

According to one arrangement a series of thin carbon rods, which rest on a larger piece of carbon or metal, or say a solid carbon cylinder encased in metal is employed. The carbon rods are enclosed in tubes to slide easily therein, and are lightly pressed down by loose weights resting on them. By means of a commutator one of the carbons only is kept in a state of incandescence at a time, and when that one from some cause is rendered inoperative, the next carbon is automatically rendered operative or incandescent.

Erratum.—In Dr. Lodge's Paper on "Energy," p. 291, line 2, col. 2, for "when" *read* "then."

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Nov. 12.		Business Done Week Ending Nov. 12. Highest.	Lowest.
Anglo-American Ordinary	56,	½	56¾	55½
Do. "B"	82,	½	82½	81¾
Do. "A"	32,	½	32⅝	31¾
Brazilian	7¼,	⅝	7⅜	7¼
Cuba	8,	½	8⅛	8
Do. Ten per Cent. Preference	15,	16	—	—
Direct Spanish	1¾,	2¼	2	2
Do. Ten per Cent. Preference	11½,	¾	11⅝	11½
Direct United States	10⅛,	⅜	10⅜	10½
Eastern	8 3-16,	5-16	8⅜	8 3-16
Do. Six per Cent. Debenture	103,	5	104	103½
Do. Five per Cent. do	103,	5	103	103
Do. Six per Cent. Preference	12,	½	12¼	12½
Eastern Extension	8 7-16,	9-16	8 9-16	8 7-16
Do. Six per Cent. Deb.	107,	9	—	—
German Union	7¼,	¾	—	—
Globe Telegraph and Trust	5,	⅛	5¼	5
Do. Six per Cent. Preference	11,	½	11¼	11
Great Northern	8½,	¾	8⅞	8¼
Indo-European	22½,	3½	23¼	23
Mediterranean Extension	2¼,	3¼	2⅝	2⅜
Do. Eight per Cent. Preference	9¾,	10¼	10	10
Reuter's	9,	10	10	9⅞
Submarine	227,	32	231	228
West India and Panama	1⅜,	⅝	1 9-16	1⅜
Do. Six per Cent. Preference	7¼,	¾	7½	7 7-16
Western and Brazilian	4¼,	½	4¾	4 3-16
West. Union Seven per Ct. 1st Mt	120,	25	—	—
Do. Six per Cent. Sterling	105,	7	—	—

TRAFFIC RECEIPTS FOR OCTOBER, 1879.

Companies.	Oct. 1879.	Oct. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,835	165	—
Direct Spanish Telegraph Company	1,371	1,107	264	—
Direct United States Telegraph Company	26,830 estd.	—	—	—
Eastern Telegraph Company	50,251	41,678	8,573	—
Eastern Extension Telegraph Company	31,419	23,393	8,026	—
Great Northern Telegraph Company	21,987	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—

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